NAVSHIPS 900,644

UNCLASSIFIED

INSTRUCTION BOOK

for

FREQUENCY METER
MODEL TS-173/UR

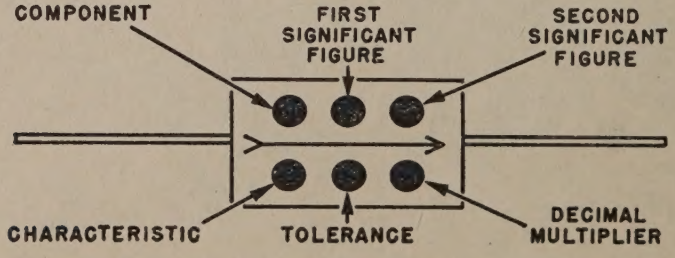
THE ALLEN D. CARDWELL MANUFACTURING CORPORATION
BROOKLYN, NEW YORK

NAVY DEPARTMENT BUREAU OF SHIPS

Contract NXsr-65277 ***Approved 10 MAY 1945***

ERRATA SHEET
for
MODEL TS-173/UR FREQUENCY METER INSTRUCTION BOOK
CONTRACT #NXSR 65277

PAGE	SYMBOL DESIG.	CORRECTION
5-0	A 101	CONTRACTOR'S PART #3.429 TO BE ADDED
5-1	C 6	JAN TYPE DESIGNATION LISTED AS CC21CF060K SHOULD READ CC21CH060D
5-1	C 7	SAME AS C 6
5-1	C 8	COLUMN 2 SHOULD READ 750mmf/mfd/C; ADD NAVY TYPE DESIGNATION CC36JL550K IN COLUMN 4
5-1	C 11	CM30B202M (COLUMN 4) SHOULD READ CM30B202K
5-1	C 13	CM35B39ZK (COLUMN 4) SHOULD READ CM35B402K
5-1	C 14	CM35B68ZK (COLUMN 4) SHOULD READ CM35B602K
5-2	C 24	COLUMN 2 — TOLERANCE SHOULD BE PLUS/MINUS 10%; CM3513500J (COLUMN 4) SHOULD READ CM20C500K
5-3	F 1	QUANTITIES SHOULD READ 40, 80, 200
5-6	J 100	NAVY TYPE NUMBER (COLUMN 4) SHOULD READ CBK 49206
5-6	J 101	NAVY TYPE NUMBER (COLUMN 4) SHOULD READ 49025B
5-6	J 102	SAME AS J 101
5-7	L 6	ADD NAVY TYPE CFX302815; FREED PART # SHOULD READ 12429
5-8	R 1	COLUMN #2 — TOLERANCE SHOULD BE PLUS/MINUS 10%
5-9	R 5	SAME AS R1
5-9	R 8-10-11	SAME AS R5
5-10	S 1	DATA IN COLUMNS 7 & 8 SHOULD BE INTERCHANGED
5-10	S 2	SAME AS S 1
5-10	T 1	ADD NAVY TYPE # CUT 302813
5-10	T 2	ADD NAVY TYPE # CFX 302814
5-12	TABLE 5-3	ADD JAN COLOR CODE (SEE FIGURE BELOW)



NAVSHIPS 900,644 RESTRICTED

INSTRUCTION BOOK

for

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MODEL TS-173/UR

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NAVY DEPARTMENT

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10 May 1945

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/s/ J. B. DOW
By direction

RECORD OF CORRECTIONS MADE

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CONTRACTUAL GUARANTEE

The equipment including all parts and spare parts, except vacuum tubes, batteries, rubber and material normally consumed in operation, is guaranteed for a period of one year from the date of delivery of the equipment to and acceptance by the Government with the understanding that all such items found to be defective as to material, workmanship or manufacture will be repaired or replaced, f.o.b. any point within the continental limits of the United States designated by the Government, without delay and at no expense to the Government; provided that such guarantee will not obligate the Contractor to make repair or replacement of any such defective items unless the defect appears within the aforementioned period and the Contractor is notified thereof in writing within a reasonable time and the defect is not the result of normal expected shelf life deterioration.

To the extent the equipment, including all parts and spare parts, as defined above, is of the Contractor's design or is of a design selected by the Contractor, it is also guaranteed, subject to the foregoing conditions, against defects in design with the understanding that if ten per cent (10%) or more of any such said item, but not less than two of any such item, of the total quantity comprising such item furnished under the contract, are found to be defective as to design, such item will be conclusively presumed to be of defective design and subject to one hundred per cent (100%) correction or replacement by a suitably redesigned item.

All such defective items will be subject to ultimate return to the Contractor. In view of the fact that normal activities of the Naval Service may result in the use of equipment in such remote portions of the world or under such conditions as to preclude the return of the defective items for repair or replacement without jeopardizing the integrity of Naval communications, the exigencies of the Service, therefore, may necessitate expeditious repair of such items in order to prevent extended interruption of communications. In such cases the return of the defective items for examination by the Contractor prior to repair or replacement will not be mandatory. The report of a responsible authority, including details of the conditions surrounding the failure, will be acceptable as a basis for affecting expeditious adjustment under the provisions of this contractual guarantee.

The above one year period will not include any portion of time the equipment fails to perform satisfactorily due to any such defects, and any items repaired or replaced by the Contractor will be guaranteed anew under this provision.

INSTALLATION RECORD

Contract Number NXsr-65277 Date of Contract 6 June 1944.....
Serial Number of equipment .....
Date of acceptance by the Navy .....
Date of delivery to contract destination .....
Date of completion of installation .....
Date placed in service .....

REPORT OF FAILURE

Report of failure of any part of this equipment, during its service life, shall be made to the Bureau of Ships in accordance with current instructions. The report shall cover all details of the failure and give the date of installation of the equipment. For procedure in reporting failures see Chapter 67 of the "Bureau of Ships Manual", or superseding instructions.

ORDERING PARTS

All requests or requisitions for replacement material should include the following data:

1. Navy stock number or, when ordering from an Army supply depot, the Army stock number.
2. Name of part.

If the Navy stock number has not been assigned, the requisitions should specify the following:

1. Equipment model designation.
2. Name of part and complete description.
3. Manufacturer's designation.
4. Contractor's drawing and part number.
5. AWS, JAN, or Navy type designation.

DESTRUCTION OF ABANDONED MATERIEL IN THE COMBAT ZONE

In case it should become necessary to prevent the capture of this equipment, and when ordered to do so, DESTROY IT SO THAT NO PART OF IT CAN BE SALVAGED, RECOGNIZED, OR USED BY THE ENEMY, BURN ALL PAPERS AND BOOKS.

Means:

1. Explosives, when provided.
2. Hammers, axes, sledges, machetes, or whatever heavy object is readily available.
3. Burning by means of incendiaries such as gasoline, oil, paper or wood.
4. Grenades and shots from available firearms.
5. Burying all debris, or disposing of it in streams or other bodies of water, where possible and when time permits.

Procedure:

1. Obliterate all identifying marks. Destroy nameplates and circuit labels.
2. Demolish all panels, castings, switch and instrument boards.
3. Destroy all controls, switches, relays, connections and meters.
4. Rip out all wiring and cut interconnections of electrical equipment. Smash gas, oil, and water cooling systems in gas engine generators, etc.
5. Smash every electrical or mechanical part, whether rotating, moving or fixed.
6. Break up all operating instruments such as keys, phones, microphones, etc.
7. Destroy all classes of carrying cases, straps, containers, etc.
8. Bury or scatter all debris.

DESTROY EVERYTHING!

SAFETY NOTICE

The attention of officers and operating personnel is directed to Chapter 67 of Bureau of Ships Manual or superseding instructions on the subject of Radio-Safety precautions to be observed.

RESUSCITATION

AN APPROVED POSTER ILLUSTRATING THE RULES FOR RESUSCITATION BY THE PRONE PRESSURE METHOD SHALL BE PROMINENTLY DISPLAYED IN EACH RADIO, RADAR OR SONAR ENCLOSURE. POSTERS MAY BE OBTAINED UPON REQUEST TO THE BUREAU OF MEDICINE AND SURGERY.

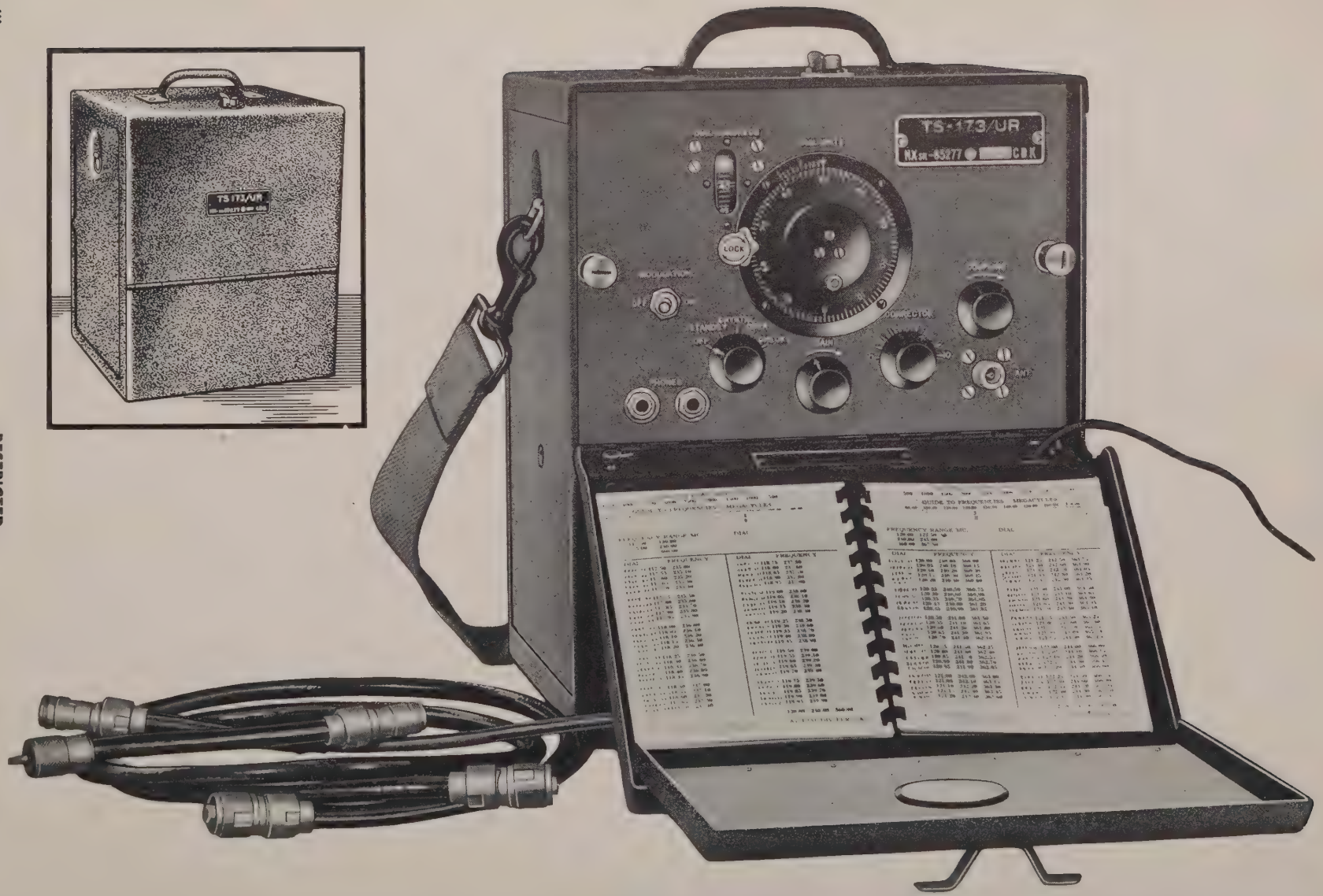


Fig. 1-1. Frequency Meter TS-173/UR and Accessories.

SECTION 1 — GENERAL DESCRIPTION

1. INTRODUCTION.

a. This instruction book covers the TS-173/UR, heterodyne frequency meter and crystal controlled calibrator. The equipment measures the frequency of an r-f signal within the range of 90 to 450 megacycles, and enables transmitters and receivers operated on this range to be calibrated by the zero-beat method.

The equipment is designed for power supply or battery operation, and is used aboard ship either as a portable or permanent installation. The overall dimensions are indicated on figure 1-2.

Both the frequency meter chassis and the power supply are housed in a carrier-type metal case CY-133/-UR having two compartments. When battery operation is required, the power supply which is housed in the lower compartment, figure 1-3, can be removed from its frame. This frame is convertible into a tray capable of holding six 22.5-volt batteries and four 1.5-volt batteries; these supply 135 volts and 6 volts respectively. An antenna cable, an adapter, and a probe are normally stowed in the lower front compartment.

NOTE

For permanent installation, remove four rubber feet from bottom of cabinet and secure with four screws through holes.

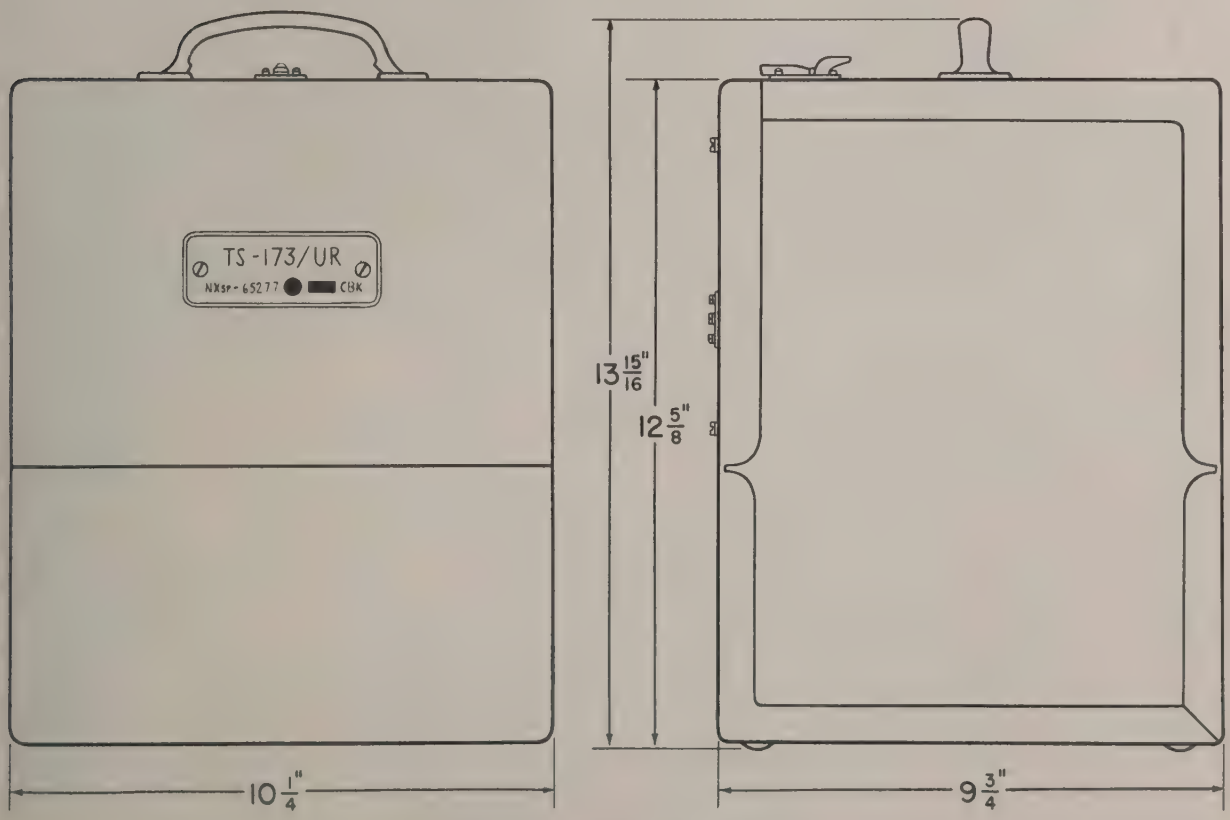


Fig. 1-2. Cabinet Dimensions.

ACCESSORIES SUPPLIED

QUANTITY	NAME	NAVY TYPE DESIGNATION	OVERALL DIMENSIONS	VOLUME (approx.)	WEIGHT (approx.)
1	Frequency Meter	TS-173/UR	Uncrated: 10¼" wide x 9⅝" long x 13 5/16" high.	Uncrated: 1080 cubic inches	Uncrated: 27 lbs.
	Antenna Equipment Including:		Crated: 12" long x 12" wide x 15" high	Crated: 5180 cubic inches	Crated: 63 lbs.
1	Coaxial Cable	CG-55/U	58" long		
1	Adapter	CG-56/U			
1	Probe Antenna	AT-66/U			

ACCESSORIES REQUIRED BUT NOT SUPPLIED

QUANTITY	NAME	JAN OR NAVY TYPE DESIGNATION	OVERALL DIMENSIONS	VOLUME (approx.)	WEIGHT (approx.)
1	Headset	49016 or equivalent			
4	1½ volt battery	JAN Type BA-23	6" high x 2 9/16" diam.		
6	22½ volt battery	JAN Type BA-2	2 19/32" high x 3 7/16" long x 2 1/32" wide		

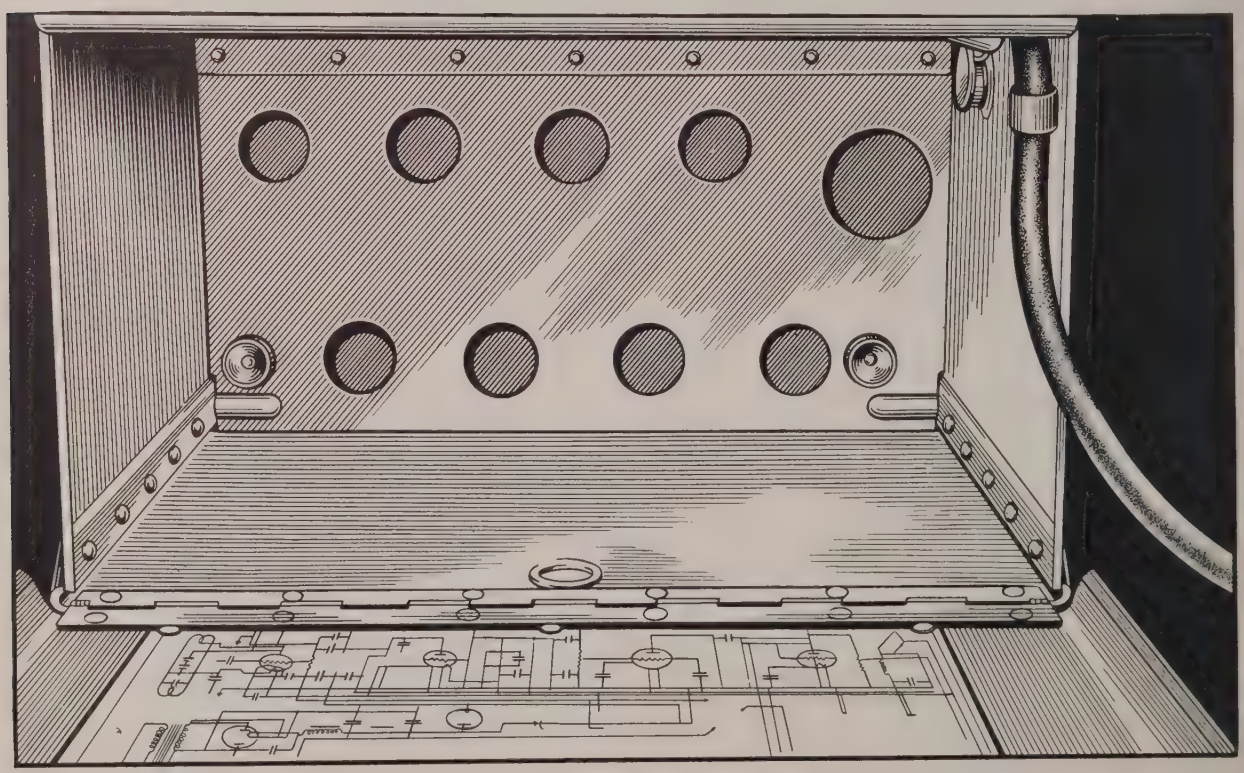


Fig. 1-3. Interior of Power Supply Compartment.

Fig. 1-4. Front View of Equipment.

2. DESCRIPTION OF FREQUENCY METER.

a. CONTROLS.—The control panel is exposed when the snap latch is released and the front cover lowered, figure 1-4. The controls are:

(1) SELECTOR SWITCH.—This is a five-position switch which performs the following functions: OFF, STANDBY, CRYSTAL, OPERATE, and CHECK.

(a) In the OFF position, the equipment is disconnected.

(b) In the STANDBY position, heater voltage is applied only to the heterodyne oscillator triode.

(c) In the CRYSTAL position, the crystal oscillator may be used to produce either a five-megacycle, modulated or unmodulated signal, or to calibrate another set at five-megacycle intervals.

(d) In the OPERATE position the heterodyne oscillator, whose output may be modulated or unmodulated, is used to determine the frequency of a received signal or to generate a signal at the desired frequency.

NOTE

The crystal oscillator does not function in the OPERATE position.

(e) In the CHECK position, both the crystal and the heterodyne oscillators are functioning so that the calibration of the heterodyne oscillator may be checked by the zero-beat method.

(2) CORRECTOR.—This control adjusts the frequency of the heterodyne oscillator to correspond with the frequency of the crystal oscillator at a CRYSTAL CHECK POINT.

(3) MODULATION.—When this switch is ON, the output of either the heterodyne oscillator or the crystal oscillator is modulated at approximately 1000 cycles per second.

(4) COUPLING.—The coupling control adjusts the degree of attenuation of an input or output signal.

(5) GAIN.—The gain control adjusts the amplitude of the audio output.

(6) DIAL HUNDREDS.—This is a drum dial on the shaft of the main tuning capacitor; it is graduated in 100 equally spaced divisions.

(7) DIAL UNITS.—The units control is a disk-type dial graduated in 100 divisions. It enables the operator to read the DIAL HUNDREDS scale accurately. One rotation of the DIAL UNITS disk moves DIAL HUNDREDS through one division. In order to improve the reading accuracy further, a vernier is provided which divides each DIAL UNITS division into tenths.

(8) LOCK.—A lock is provided on the left side of the main tuning dial. This locks the tuning capacitor in position when continuous operation at a fixed frequency is desired.

b. PANEL CONNECTIONS.

(1) ANTENNA JACK.—An antenna jack is located on the front panel. The antenna coaxial cable plugs into this jack.

(2) PHONES JACK.—Two jacks are provided.

c. CALIBRATION BOOK.—A calibration book is mounted on the front hinged cover of the instrument case, and is exposed by pulling out the handle located on the inside of the cover near the hinge. The calibration book lists the settings of the main tuning dial for any desired frequency. The first column indicates dial settings; the second column lists the fundamental frequency, the third and fourth columns list the usable harmonics for the calibrated range.

d. POWER SUPPLY PP-79/UR.—This unit, which is housed in the power supply compartment at the lower rear of the case CY-133/UR, is of the voltage-regulated type. It employs a 6X5G as a full wave rectifier and an OD3/VR150 as a voltage regulator. A cable from the panel of the power supply connects to five banana plugs mounted at the back of the cabinet behind the frequency meter, figure 1-3. Removing the meter chassis disconnects the plugs.

3. GENERAL CHARACTERISTICS.

a. FREQUENCY COVERAGE.—Frequency Meter TS-173/UR employs a type 9002 triode as a modified ultraudion oscillator. This oscillator is very stable and its frequency can be varied continuously over the entire range of 90 to 180 megacycles. To calibrate this oscillator at certain points, the output of a crystal oscillator (9002 triode) is mixed with the heterodyne oscillator output in a mixer stage. This stage uses a 9001 pentode. The fundamental crystal frequency is five megacycles, but only the 18th harmonic (90 megacycles) or higher harmonics are used. A two-stage amplifier, using a 9001 and a 9002, amplifies the mixer output so that it may be heard in a headset. The second stage of the audio amplifier, the 9002, is alternately used as a 1000-cycle audio oscillator to plate-modulate either the crystal or heterodyne oscillator outputs.

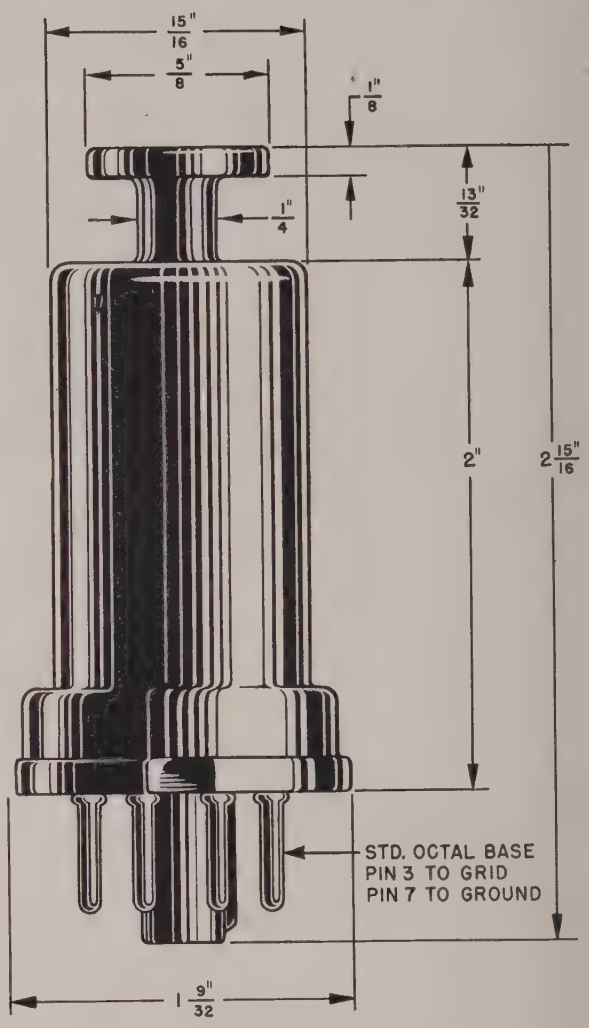


Fig. 1-5. Crystal Holder Dimensions.

b. OUTPUT VOLTAGE.—The radio-frequency output voltage will vary from approximately 465 microvolts up to 0.1 volt (100,000 microvolts) with the COUPLING control at minimum and maximum respectively. This is true for any frequency within the operating range.

c. AUDIO POWER OUTPUT.—Output audio power supplied to the headset also depends upon the COUPLING setting. At minimum the audio output power is 4 milliwatts and at maximum it may be above 75 milliwatts with GAIN control set at maximum. However, this measurement is subject to considerable variation because of the variation of signal intensity or crystal harmonic intensity.

d. SENSITIVITY.—The meter can detect a radio-frequency signal of 20 microvolts minimum input with an audio output power of from 4 to 75 milliwatts, depending upon the frequency. This is measured with the COUPLING control at maximum, i.e., turned completely clockwise.

e. SELECTIVITY.—There is no appreciable frequency selectivity; the response is essentially flat over the entire range.

f. MODULATION.—When desired, amplitude modulation can be employed. The modulation percentage is not constant but averages approximately 60 percent.

g. CRYSTAL.—The crystal, figure 1-5, is manufactured in an hermetically sealed case. It has a low temperature coefficient of 0.5 cycle per megacycle per degree centigrade, and a fundamental frequency of five megacycles.

h. FREQUENCY STABILITY.—The frequency stability of the equipment is as follows: after the warm-up period of 20 minutes, the frequency drift with respect to time is very low. Calibration accuracy after the warm-up period is within 0.005 percent at normal temperature, 20 degrees C. (68 degrees F.). Over the range of operating temperatures, 0 degrees C. to 50 degrees C. (32 degrees F. to 122 degrees F.), the change in calibration is within 0.01 percent.

i. IMPEDANCES.—The audio frequency output impedance is 600 ohms; the r-f input or output impedance is 50 ohms.

j. POWER SUPPLY CHARACTERISTICS.

Navy Type	PP-79/UR
Manufacturer	The Allen D. Cardwell Manufacturing Corporation
Primary AC Voltage	115 volts at 60 cycles
DC Output Voltage	150 volts
Filament Voltage	6.3 volts AC
Total Power Consumption	20 watts
Plate Current Output for Normal Operation	15 milliamperes
Filament Current Output for Normal Operation	0.75 amperes

Changes in line voltage up to 10 percent will not normally affect calibration. When batteries are used, a drop of 10 percent in the A or B voltages does not affect calibration since these errors and those caused by temperature changes can be compensated by the CORRECTOR.

4. TABLE OF REFERENCE DATA

The following table lists reference data for TS-173/UR.

Name of Equipment	Heterodyne Frequency Meter and Crystal Controlled Calibrator
Type Designation	TS-173/UR
Contract Number	NXsr-65277
Contract Date	6 June 1944
Contractor	The Allen D. Cardwell Mfg. Corp., Brooklyn, N. Y.
Cognizant Naval Inspector	Inspector of Naval Material New York, N. Y.
Number of packages including spares boxes	2 packages
Frequency Range	90 to 450 megacycles
Oscillator Fundamental Range	90 to 180 megacycles
Crystal Calibrator	5 megacycle, crystal-controlled oscillator
Crystal Designation	NAVY TYPE CG-40175-CG CRYSTAL FREQUENCY 5000.0 KC NXsr-65277
Modulation Characteristics	Approximately 60% amplitude modulation at about 1000 cycles
Operating Voltage	115 volts at 60 cycles On batteries: 135 volts B + supply and 6 volts heater supply Permissible variation: ± 10 volts
Total Weight	
Uncrated	27 lbs.
Crated	63 lbs.
Total Volume	
Uncrated	1080 cubic inches
Crated	5180 cubic inches
Dimensions	10¼" wd x 9⅝" lg x $13\frac{5}{16}$" h
Power Requirement	20 watts
Radio-Frequency Impedance	50 ohms
Tube Complement	3 tubes of type 9002 2 tubes of type 9001 1 tube of type 6X5G 1 tube of type VR150

SECTION 2 — THEORY OF OPERATION

1. GENERAL DESCRIPTION OF CIRCUITS.

Frequency Meter TS-173/UR comprises an electrical circuit, figure 2-1, with five principal parts as follows:

a. HETERODYNE OSCILLATOR.—This is a continuously variable, ultraudion oscillator whose fundamental frequency range is 90 to 180 megacycles. The oscillator fundamental and harmonics can be accurately tuned to cover the entire band between 90 and 450 megacycles.

b. CRYSTAL OSCILLATOR.—The crystal oscillator generates the signal used as the frequency standard. The fundamental frequency is five megacycles, but the band usually used extends from the 18th to the 36th harmonic (90 to 180 megacycles). The oscillator can also be used as a generator for a five-megacycle signal or, for harmonics spaced five megacycles apart. These signals can be modulated or unmodulated.

c. MIXER.—The mixer stage provides a means of mixing the crystal oscillator and the heterodyne oscillator outputs when the selector switch is in the CHECK position.

When the selector switch is in the OPERATE position, the mixer tube mixes the external signal and the heterodyne oscillator signal to produce a beat note in the output circuit.

In the CRYSTAL position this tube provides sufficient coupling to the antenna for transmission of the crystal oscillator signal and is also capable of mixing an external signal and the crystal oscillator signal to produce a beat note.

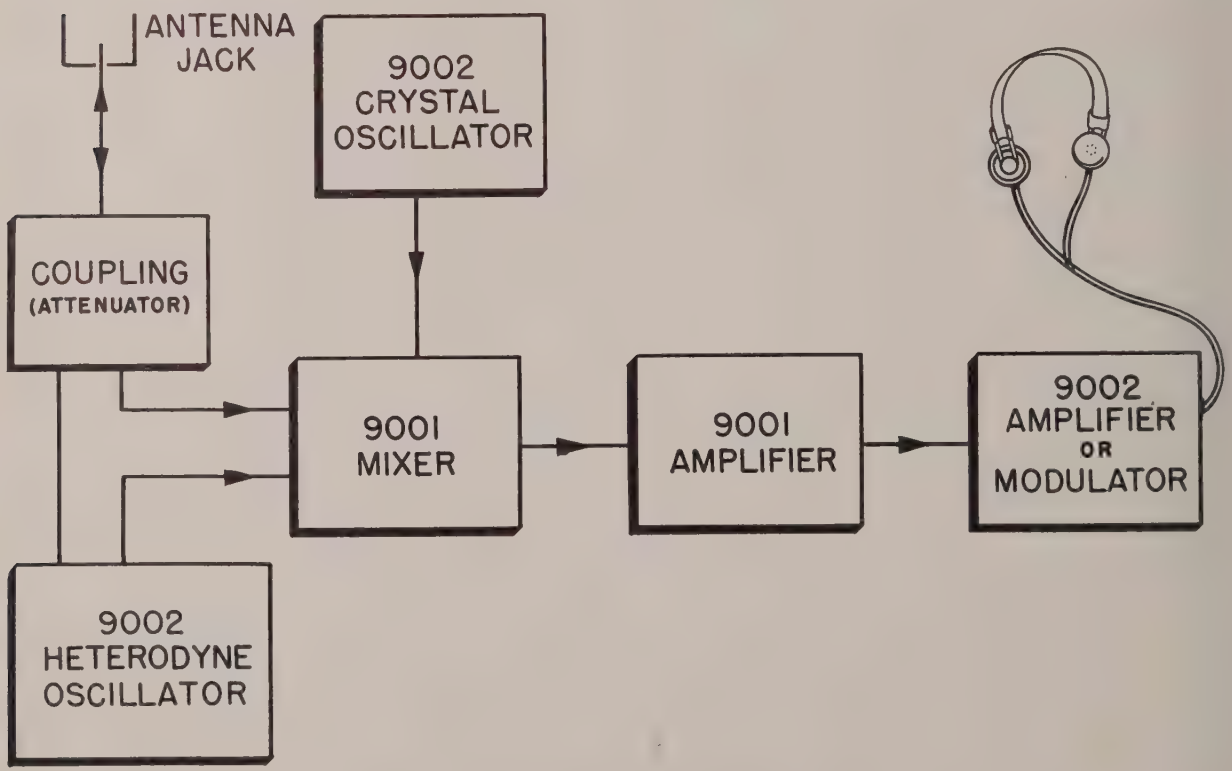


Fig. 2-1. *Block Diagram of TS-173/UR Circuit.*

d. AUDIO AMPLIFIER AND MODULATOR.—The output from the mixer stage is amplified by a two-tube amplifier, the last stage of which may be switched and made to oscillate at approximately 1000 cycles per second. The audio signal is used to plate-modulate the ultraudion oscillator or the crystal oscillator output when the modulator switch is in the ON position. If no modulation were provided, the signal generated by the heterodyne frequency meter could not be heard in receivers equipped for audio detection only.

2. CIRCUIT THEORY.

a. TUBES.—The tubes used in this set are miniature tubes designed particularly for use at relatively high frequencies. The 9001 is a sharp cut-off pentode and the 9002 is a triode. Inter-electrode capacitances are decreased by using small cathodes, grids, and plates. Low lead inductances and short internal leads are obtained by using a glass button stem structure and single end design. There are two cathode leads in each tube to reduce common feedback inductance.

NOTE

Except for the heterodyne oscillator triode, tubes of the same type may be interchanged without affecting calibration.

b. CRYSTAL OSCILLATOR.

(1) DESCRIPTION.

(a) In the functional diagram of the crystal oscillator, figure 2-2, the crystal is shown encircled because it actually is placed inside an hermetically sealed metal envelope. The base fits the standard octal socket and the top of the envelope is shaped to provide a handle for gripping. The crystal has a temperature coefficient of approximately one-half cycle per megacycle per degree centigrade.

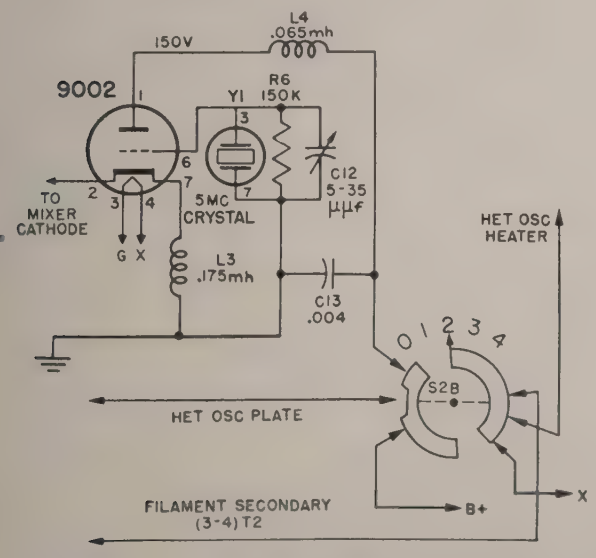


Fig. 2-2. Functional Diagram of Crystal Oscillator—S2 at CRYSTAL.

(b) Plate inductor L4 is a choke whose inductance and distributed capacitance provide the plate-tuned circuit.

(c) Choke L3 in the crystal cathode circuit is also in the mixer cathode circuit and provides coupling.

(d) Resistor R6 in parallel with the crystal functions as a grid leak, and capacitor C12 corrects crystal capacitance. Although variable, *this capacitor is preset at the factory for accurate calibration and should not be disturbed.*

(e) Capacitor C13 is a bypass between B + and ground.

(f) Switch S2 is a two-deck, five-position switch and in figure 2-2 is set at CRYSTAL position. In this position, B + voltage is applied, and the crystal oscillator supplies a signal to the mixer stage.

(2) OPERATION.

(a) Operation may be ascertained by examination of the simplified schematic of the crystal oscillator, figure 2-3. The distributed capacitance of inductor L4 is shown by dashed lines. The circuit is a standard plate-tuned crystal oscillator. The oscillator oscillates by virtue of the feedback coupling between the grid and plate circuits. The high L/C ratio of the plate circuit assists in giving high oscillator stability.

(b) Feedback is obtained by the grid to plate capacitance of the triode 9002. This is shown in figure 2-3 as Cgp. When switch S2 is turned to CRYSTAL, plate voltage is applied and a voltage is impressed across the Plate-Cgp-R6-Ground circuit. The voltage across R6, which is also across the crystal, causes the crystal to

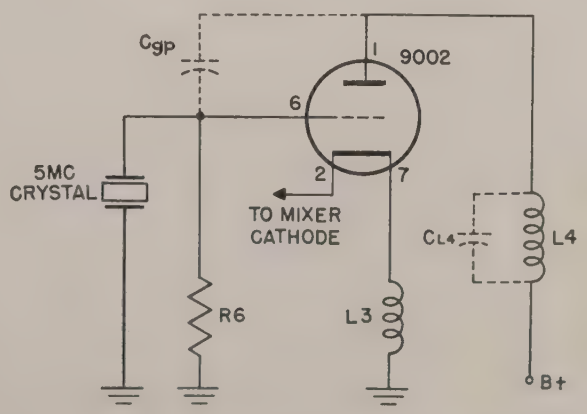


Fig. 2-3. Simplified Schematic of Crystal Oscillator.

compress (Piezo-Electric Effect). The crystal will tend to expand because of its own elastic reaction. This reaction will be reinforced by the diminishing of the resistor voltage drop which obeys the law of exponential decrease in an RC circuit. During expansion, a voltage opposite in sign to the original impressed voltage will occur between the crystal plates, i.e. between grid and cathode. The plate current will vary in proportion to the degree of grid voltage change. Because of amplification and change in sign, a larger voltage is fed back to the crystal circuit in correct phase to start the cycle again.

(c) Although the plate-tuned circuit L4 will resonate to some degree at all harmonics, the cathode choke L3 presents an impedance which increases in direct proportion to the frequency. This choke, also in the mixer cathode circuit, feeds crystal oscillator output into the mixer circuit. The higher harmonics, therefore, present a larger voltage drop across the common cathode impedance, offsetting attenuation.

c. HETERODYNE OSCILLATOR.

(1) DESCRIPTION.

(a) This oscillator is of the ultraudion type often employed for higher frequencies. It is manufactured as a unit and mounted on a Mycalex base. On the functional diagram of the heterodyne oscillator circuit, figure 2-4, switch S1 is in the OFF position and S2 is at OPERATE.

(b) L1 and L2 are two space-wound inductors; the inductance of L1 is fixed, but the inductance of L2 may be varied by means of a silver-plated brass washer mounted on an insulating shaft. The CORRECTOR on the control panel rotates this shaft to compensate for temperature drift.

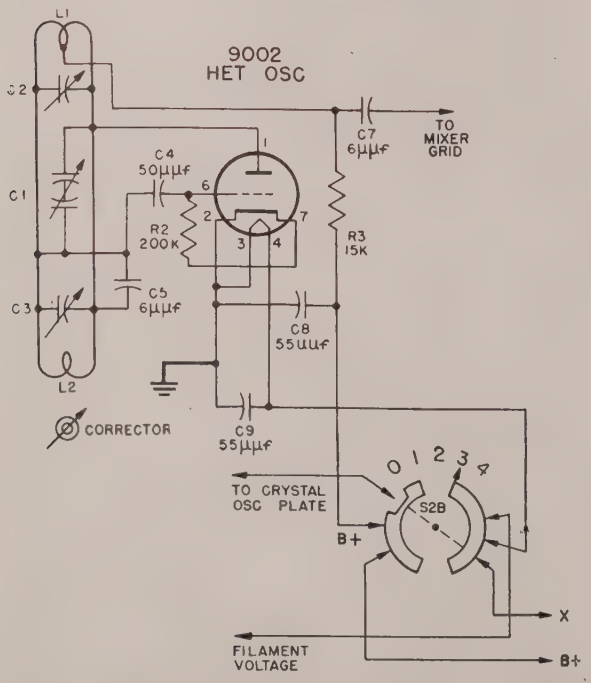


Fig. 2-4. Heterodyne Oscillator with S2 at OPERATE.

(c) The angle at which the washer cuts the longitudinal axis of coil L2 varies from 0 to 90 degrees. Minimum inductance occurs at 90 degrees or when the disk is parallel with the top of the coil.

(d) Tuning capacitor C1 is designed for straight-line frequency tuning and is constructed by mounting the rotors of two equal capacitors on a metal shaft. To eliminate tuning noise, the rotor is floated, i.e., no wiping contacts are used, and connections are made only to the stators. Since the rotors are electrically connected, the two capacitors are in series. C4, C5, and C7 are silver-on-ceramic fixed capacitors; C5 being a padder condenser to increase the total capacitance of C1, and C3, an oscillator trimmer, is used across C1 for fine adjustments. C2 is used for temperature compensation. C8 and C9 are bypass capacitors of the feed-through type and are mounted on the walls of the oscillator shield.

(e) Oscillator heater voltage is applied when switch S2 is at STANDBY and for all subsequent positions of this switch.

NOTE

If adjustment is required, or when oscillator tube replacement is made, follow instructions listed in section 4, paragraph 2*c*.

(2) OPERATION.

(a) Since the inductance in the oscillator circuit consists of L1 and L2 in parallel, and because the inductance of L1 equals L2, the total inductance in the circuit is half that of either coil.

(b) C1, consisting of two capacitors in series, has an effective capacitance one-half that of either capacitor. The total capacitance will be the sum of C1, C2, C3, and C5. Total values of inductance and capacitance are represented as L and C, in figure 2-5A.

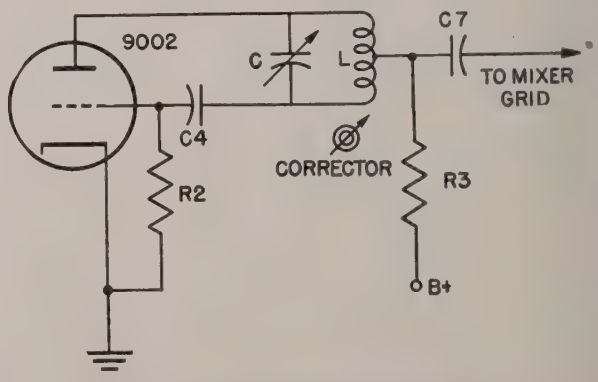


Fig. 2-5A. Simplified Schematic of Heterodyne Oscillator.

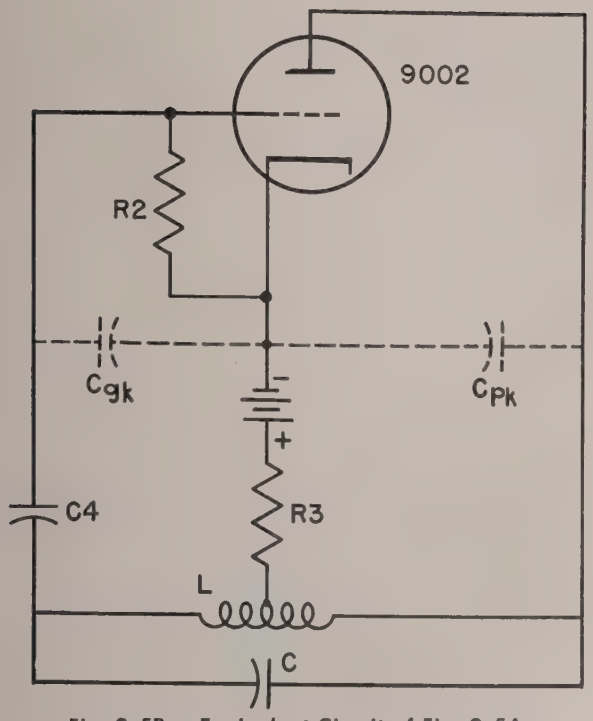


Fig. 2-5B. Equivalent Circuit of Fig. 2-5A.

(c) The ultraudion oscillator can be analyzed by considering the plate-to-cathode capacitance and the grid-to-cathode capacitance inserted in the circuit as shown in figure 2-5B. The circuit is now equivalent to a Colpitts oscillator in which Cgk and Cpk function as a voltage divider to determine the amount of feedback. Decreasing Cgk will increase the voltage fed back to the grid.

(d) Tank circuit constants consist of the series arrangement of C1, Cgk, Cpk, and C4 in parallel with L. C4, large in comparison with the other capacitances, offers low impedance at high frequencies. This does not affect the frequency of oscillation. The plate supply to the tank circuit is furnished by tapping L1 at its electrical center. With this arrangement, the tap is always at a low r-f potential which is kept constant by using a resistor R3 in place of the usual r-f choke. This is because the impedance of a choke, and therefore the degree of coupling to the mixer or antenna, would increase with frequency. Furthermore, to obtain zero beat in the mixer output, a low ratio of input signal voltage to local oscillator voltage is required.

(e) The heterodyne oscillator uses self bias instead of fixed bias. Since class C operation is required for proper oscillation, high negative bias if applied at a fixed voltage, would prevent the flow of plate current. This is the reason for the bias arrangement of figure 2-4. After oscillations are built up, capacitor C4 is slightly charged whenever the tube grid becomes positive in sign. The grid side of the capacitor will be at a lower potential since electrons accumulate there. Between positive peaks, the negative charge leaks off through R2 to ground. This build-up action continues until the grid is at a sufficiently negative bias so that only a small charge accumulates on the positive grid-voltage peak and leaks off in the interval between peaks. Equilibrium is thus established and maintained at a negative potential providing sufficient bias for class C operation.

d. MIXER.

(1) DESCRIPTION.—The mixer tube is a 9001 sharp cut-off pentode, cathode coupled to the crystal oscillator through a common inductor L3, figure 2-6. R4 is the grid resistor to ground, C11 is the bypass capacitor for the screen grid, and R5 is the screen voltage dropping resistor. In the plate circuit C24 is a bypass capacitor to ground, L5 is a radio-frequency choke, R7 is a plate resistor and C15 is a bypass capacitor to ground.

The mixer is operative in the CRYSTAL, OPERATE, and CHECK positions of the selector switch.

(2) OPERATION.

(a) ON CHECK.

1. In this position, both the heterodyne oscil-

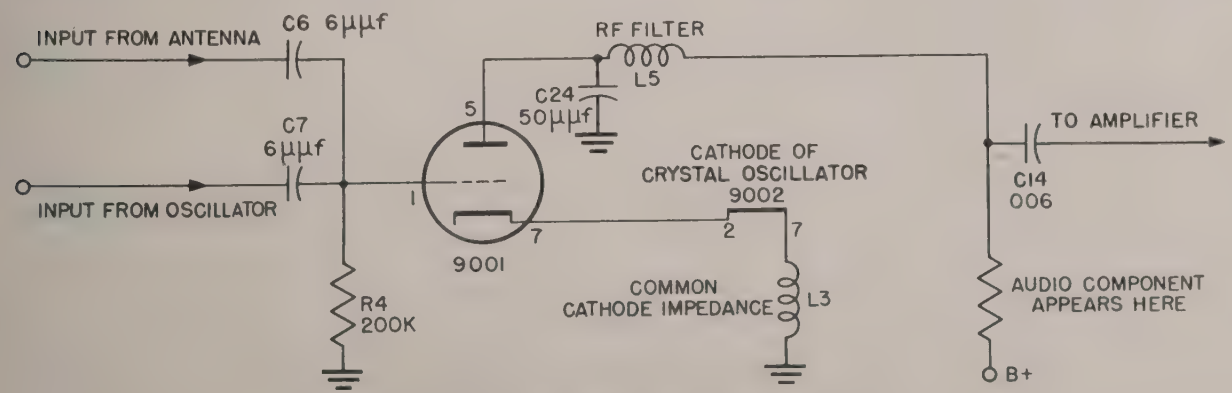


Fig. 2-6. Simplified Mixer Schematic.

lator and the crystal oscillator are functioning. The heterodyne oscillator signal is impressed on the control grid of the mixer and the plate current varies at the same rate. As mentioned previously in the description of the crystal oscillator, the cathode impedance for both mixer and crystal oscillator tubes is common, and the mixer tube plate current flows through L3. The plate current then will be modulated at the crystal oscillator frequency and at all its harmonics. All these component frequencies will be present in the plate current.

2. As C1 is tuned, the oscillator fundamental frequency or an harmonic will approach some harmonic between the 18th and the 36th harmonic of the crystal frequency. The result will be an audio note if the difference of the two frequencies is in the audio range. This audio note will be present in the mixer output, figure 2-6.

3. A radio-frequency filter, C24, L5, C15, filters out the unwanted frequencies and the audio voltage component appears across R7 to be amplified in the next stage.

(b) ON OPERATE.

1. In this position the crystal oscillator does not function, and the mixer operates primarily as a grid-leak detector. When a signal to be measured is fed into the antenna jack J100, it may be attenuated by adjusting the COUPLING control, and is impressed on the control grid of the mixer tube. This voltage is now across R4, the 200,000-ohm grid leak resistor. Another signal from the heterodyne oscillator is simultaneously being impressed on the same grid and its r-f voltage drop is also present across R4. The resultant of the two voltages across R4 can be considered as an r-f carrier modulated by the beat frequency of the two input signals. If the signals are close enough in frequency, the beat frequency will be in the audio range.

2. A grid leak detector may be considered as a diode detector plus a triode amplifier; the diode consisting of grid and cathode, the triode, of plate, grid, and cathode. It may be seen from figure 2-7 that the signal on the grid consists of an r-f carrier with a modulating component. The grid-diode action rectifies the modulation component which is then amplified. The plate current will be a radio-frequency carrier plus an audio component. The carrier is filtered out by C24, L5 and C15. The lower, audio frequency component, is not bypassed by the filter and an amplified audio voltage appears across R7.

(c) ON CRYSTAL.—In this position the mixer has two functions.

1. It provides antenna coupling to the crystal oscillator by means of control grid-to-cathode capacitance.

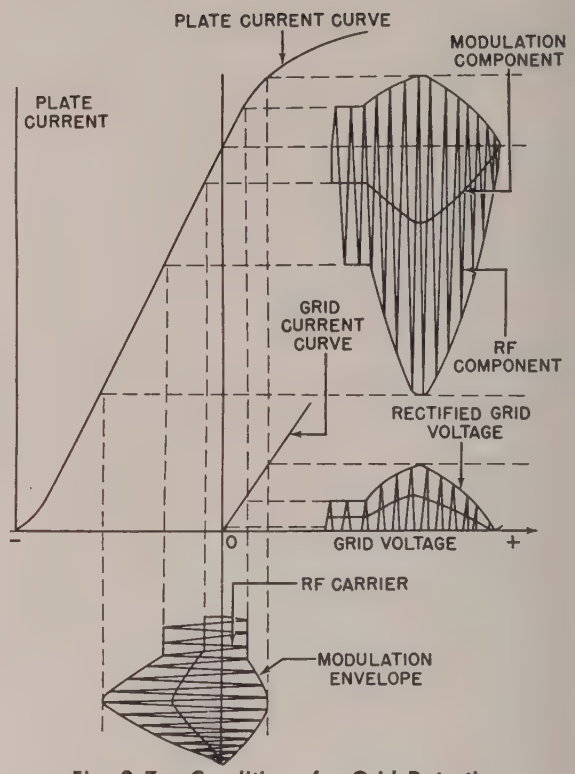


Fig. 2-7. Conditions for Grid Detection.

2. It provides a means of heterodyning an incoming signal against the crystal oscillator signal.

The theory in this case is identical with that in paragraph 2*d* (2)*(a)* of this section except that the signal on the mixer grid now comes from the antenna instead of the heterodyne oscillator.

This is the position to be used when it is desired to calibrate a transmitter or a signal generator at five megacycles or in five-megacycle steps commencing at five megacycles. At this setting an output signal of five megacycles can be obtained from the antenna jack and may be used for the same purposes as the heterodyne oscillator.

e. AMPLIFIER.

(1) DESCRIPTION.

(a) The amplifier section is a two-stage resistance coupled amplifier. The first tube is a 9001 sharp cut-off pentode using cathode bias developed across R9. R8, the GAIN control, is used to vary the amount of audio frequency voltage being amplified. C14 is a blocking capacitor, C16 is a cathode bypass capacitor, C17 is a screen grid bypass capacitor, and R10 is a screen grid voltage dropping resistor.

(b) The second stage is a 9002 triode also cathode biased for class A operation. The primary of transformer T1 is in the plate circuit and the secondary fur-

nishes the signal to jacks J101 and J102 which are connected in parallel. Output impedance is 600 ohms.

(c) S1 is the MODULATION ON-OFF panel switch. When ON, either the heterodyne oscillator or crystal oscillator is modulated for detection in receivers without beat frequency oscillators. This depends, however, upon whether the operating switch is at OPERATE or CRYSTAL.

(2) OPERATION.

(a) The first stage of the amplifier is a conventional class A pentode voltage amplifier. Bias is obtained by a cathode resistor R9. The voltage developed across it is approximately two volts positive with respect to ground; therefore the grid bias is approximately two volts. R11 is the plate resistor and C18 is a blocking capacitor. Coupling into the triode 9002 is furnished by grid resistor R12. This stage is a power amplifier, cathode biased, and T1 provides correct impedance matching for the headset.

NOTE

In figure 2-8 the SELECTOR switch is at OPERATE.

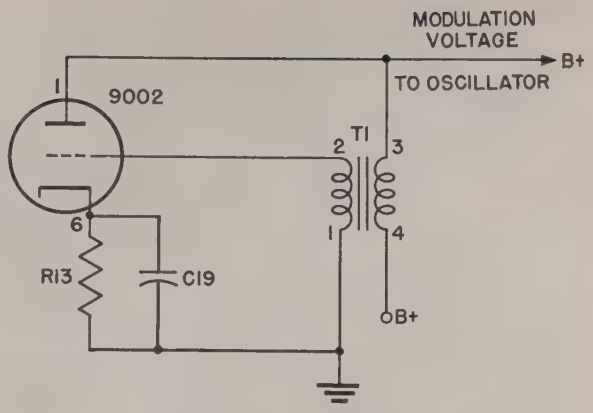


Fig. 2-9. Audio Oscillator Simplified Schematic.

(b) When it is desired to modulate the output frequency of the heterodyne oscillator, the MODULATION switch S1 is snapped to the ON position. Figure 2-9 shows how the second stage of the amplifier is modified by this change. It is converted from a power amplifier to an audio oscillator in which T1 provides inductive coupling between the grid winding (1-2) and the

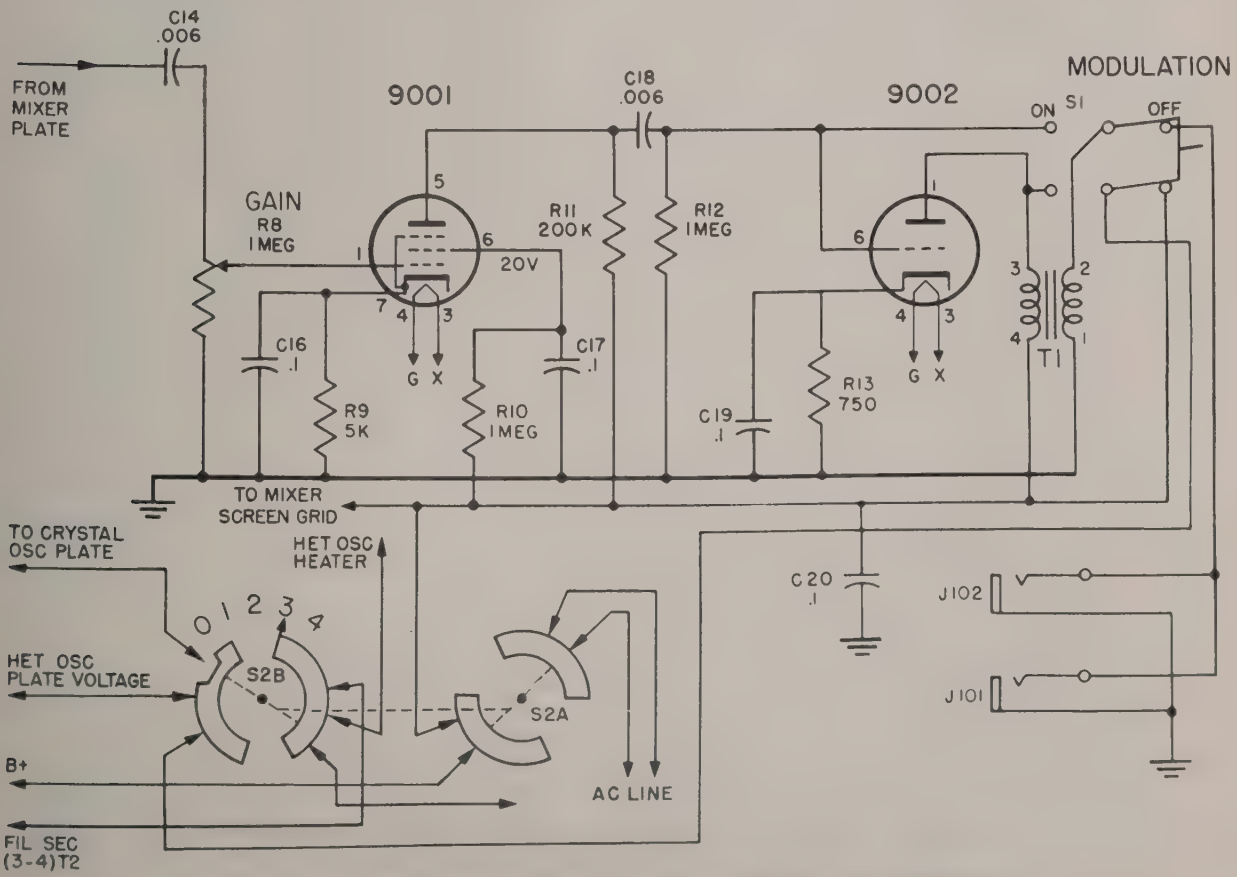


Fig. 2-8 Amplifier Section with Modulation Switch Off and S2 at OPERATE.

plate winding (3-4). Oscillation occurs at an audible rate of approximately 1000 cycles per second. Since the plate voltage for the heterodyne oscillator is now in series with the voltage across the winding (3-4), the heterodyne oscillator will be plate modulated at about 1000 cycles.

NOTE

When S1 is ON, phone jacks J101 and J102 are disconnected.

f. ATTENUATOR.—The COUPLING control on the panel varies the amount of attenuation of either input or output signals. R1 is actually two 1000-ohm potentiometers coupled to obtain maximum resistance when turned completely clockwise, and zero resistance when turned completely counterclockwise. The two sliding arm contacts are electrically connected. The equivalent circuit of the attenuator, figure 2-10, can be thought of as two resistors with a common shorting contact between them. In the maximum position the resistors are shorted out, and in the minimum position the total resistance of 2000 ohms is in series with the antenna.

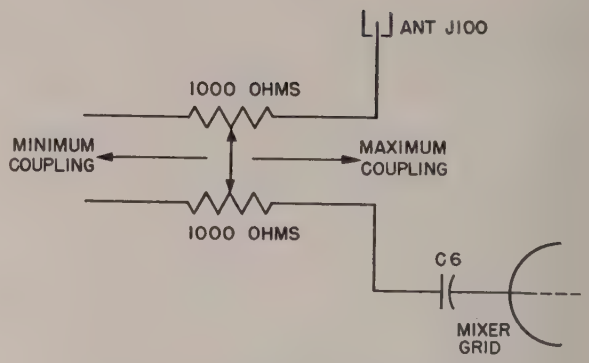


Fig. 2-10. Equivalent Attenuator Circuit.

g. POWER SUPPLY.—The power supply furnished with TS-173/UR is a low voltage, voltage regulated type. A full wave rectifier type 6X5G is used. The filter is a two-pi section type (C23, L6, C22, L7, C21) with capacitor input across C23. The OD3/VR150 is the voltage regulator tube and maintains a constant output at 150 volts under load.

SECTION 3 — OPERATION AND ADJUSTMENT

1. PREPARATION FOR USE.

a. UNPACKING.—The frequency meter is supplied with the crystal and all tubes in their proper sockets, a complete set of spare tubes, a spare crystal, and a Bristo wrench in a rack behind the chassis, figure 3-1. As supplied the power supply PP-79/UR is properly connected. The power cord, which is located in the compartment just below the frequency meter, is led out through an indentation in the compartment cover and may be plugged into any wall or deck outlet supplying 115 volts 50-60 cycles. Also housed in the same compartment is the antenna equipment. This equipment includes the units itemized in the "Accessories Supplied" table in Section 1. Inspect the cable for kinks, breaks,

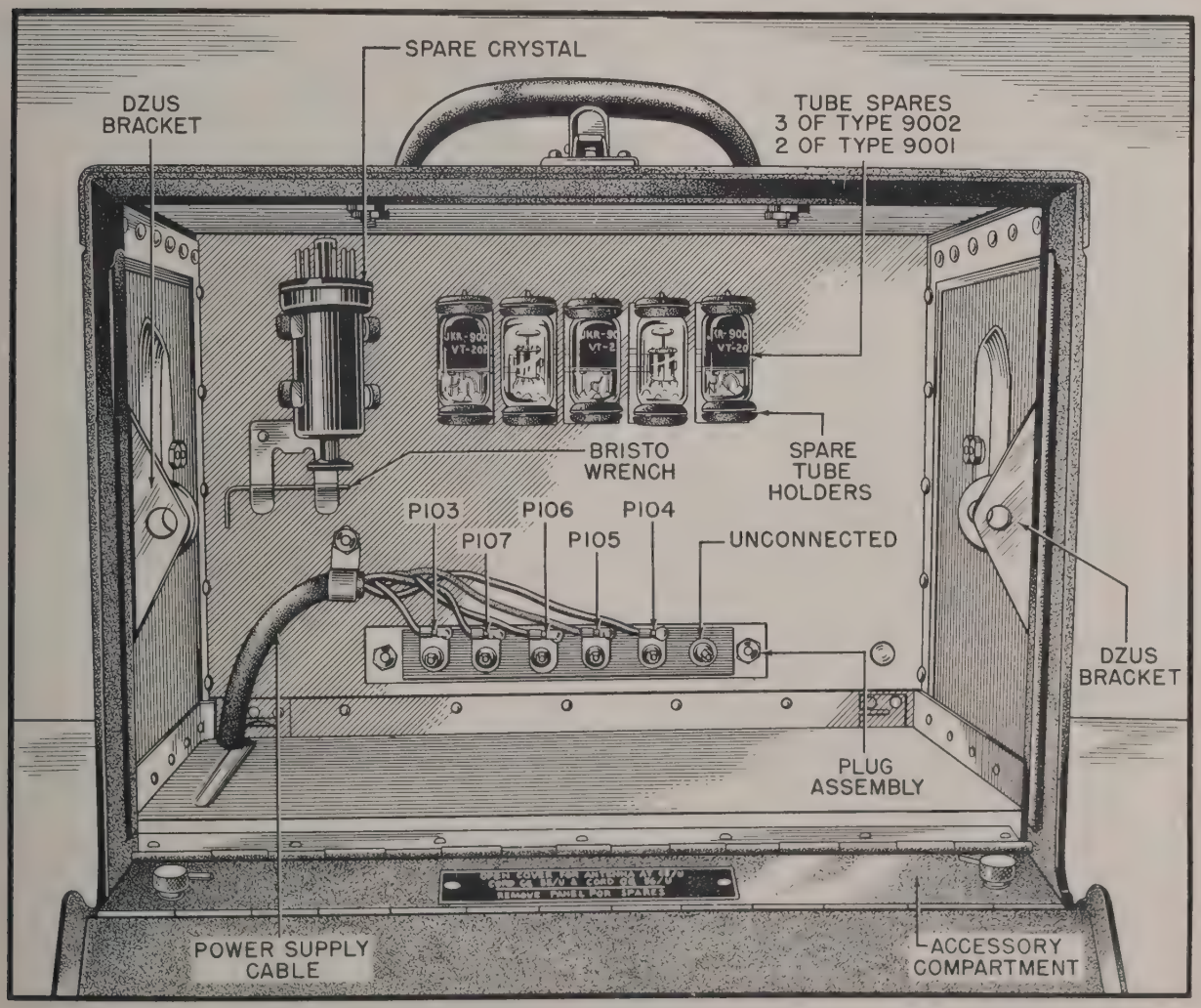


Fig. 3-1. Location of Equipment Spares.

etc. Make sure all connectors are secure and free from excess solder, dirt, etc. A calibration book in the front cover compartment is fastened to the cover and designed for use in this position. Do not remove it.

WARNING

The frequency meter is used with the front cover open. Before shutting this cover, make sure the power cord is back in its compartment.

b. INSTALLATION OF BATTERIES.—When battery operation is required, the procedure for installing batteries is as follows:

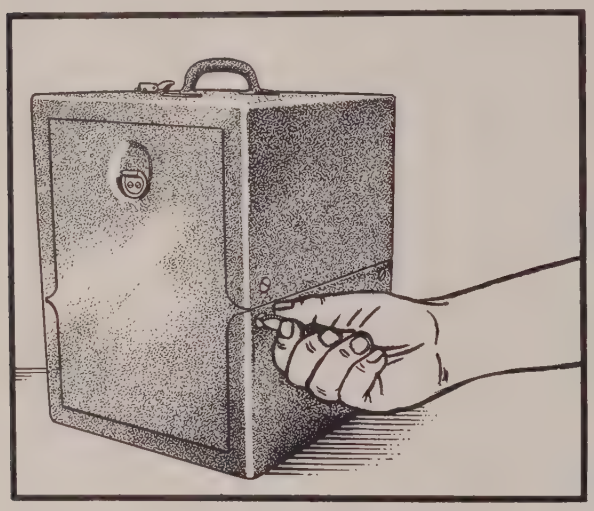


Fig. 3-2. Opening Rear Compartment.

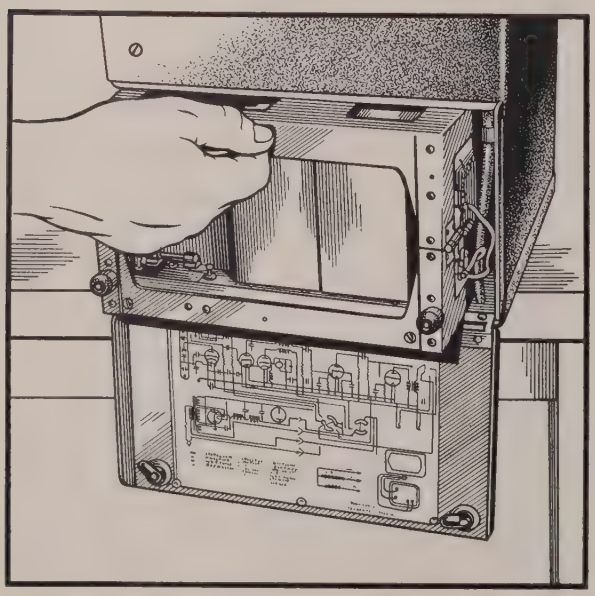


Fig. 3-3. Withdrawing Power Supply Tray.

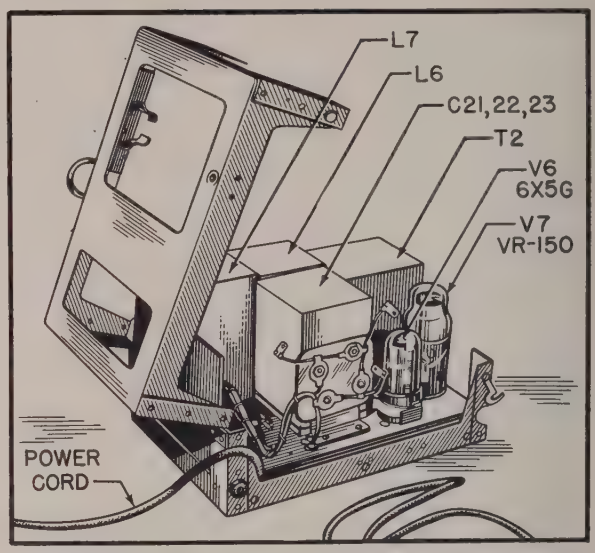


Fig. 3-4. Power Supply—Showing Components.

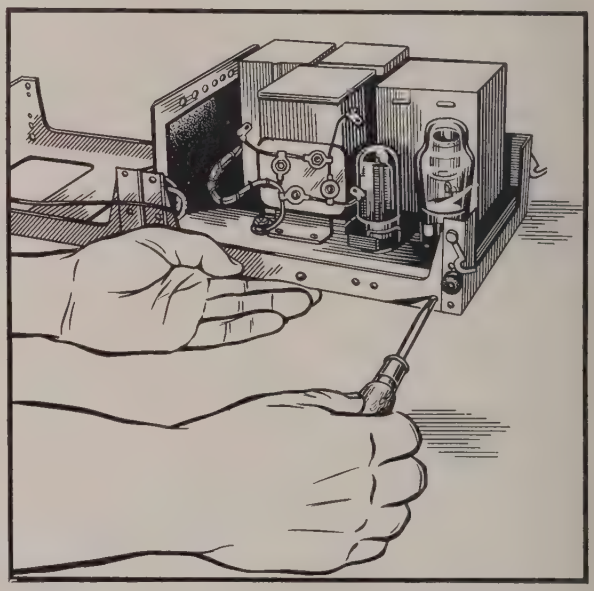


Fig. 3-5. Unscrewing Power Supply From Tray.

(1) Remove the frequency meter from the case.

(2) Select four BA-23 batteries each of which measures 1.35 volts or higher and six BA-2 batteries each of which measures 20.25 volts or higher. Test the batteries as outlined in Section 4, paragraph 1*b*.

NOTE

For the longest service, use only those batteries with the highest voltage. Do not install batteries which measure lower than voltages specified above except for emergencies.

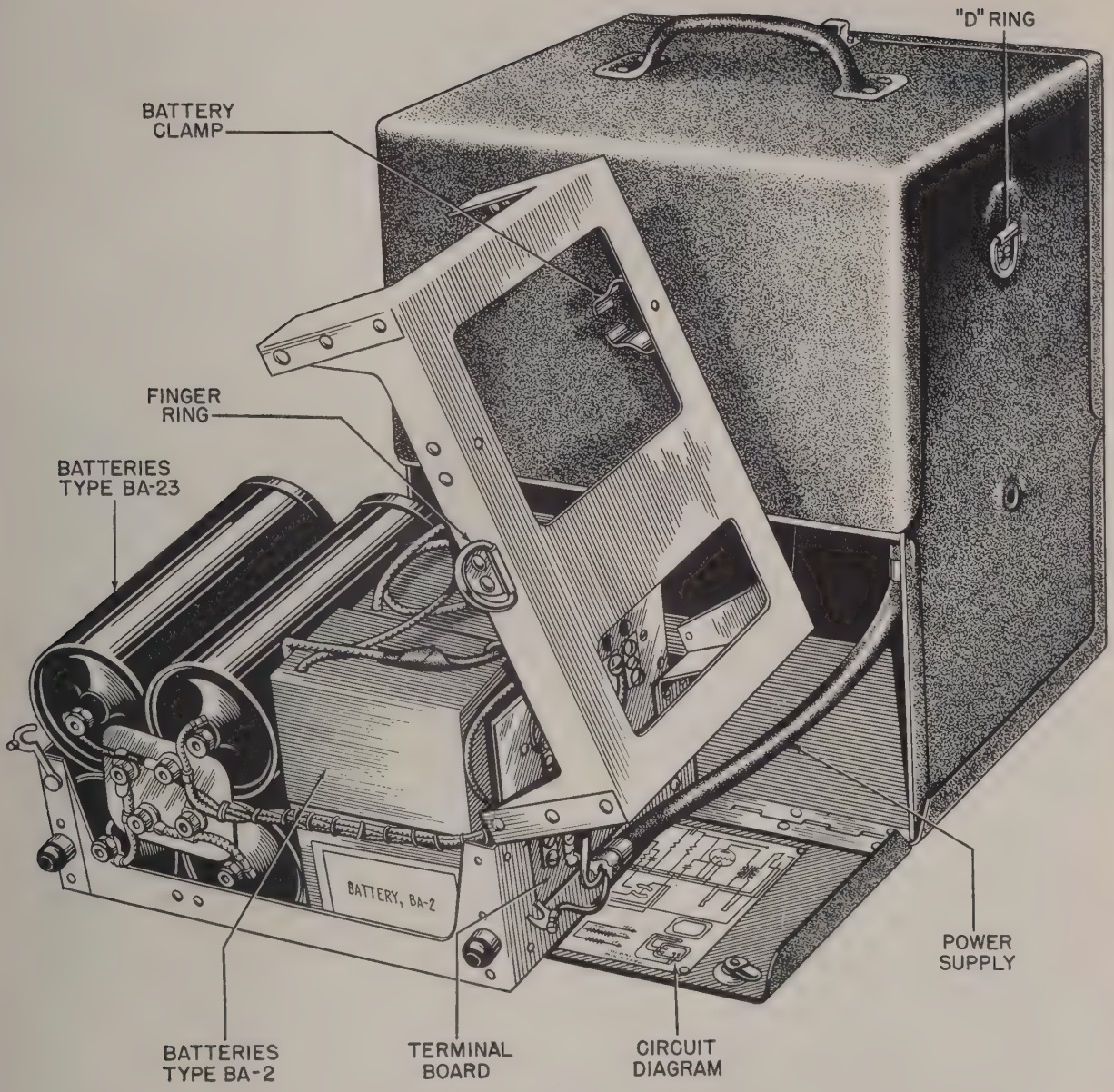


Fig. 3-6. Power Supply Tray Open—Loaded.

(3) Release the two Dzus fasteners on the rear compartment door by revolving them a half turn with a small coin, figure 3-2. Open the door.

(4) Pull out the power supply tray by grasping the ring at the top of the tray, figure 3-3.

(5) Release the two hooks holding the halves of the tray together, figure 3-4. Remove the power supply by disconnecting the captive screw leads and unscrewing the captive screws at the base, figure 3-5. Now lift out.

(6) Place three BA-2 batteries right side up in the lower right section of the tray close to the terminal panel.

(7) Bring the black lead of the first battery through the first minus hole in the lower row of holes in the terminal panel. Connect it to the top terminal screw of the double connector labeled A— B—.

(8) Bring the red lead through the adjacent plus hole and connect it to the lower terminal screw on the same connector.

(9) Successively pull the leads of the other batteries

through, and connect them to the terminal screws corresponding to their positions.

(10) Put the other three batteries upside down over the first group. Pull these leads through the top row of holes in the terminal panel and connect them to the terminal screws corresponding to their positions.

(11) Remove the nuts on the binding posts of the BA-23 batteries. Put these batteries in the tray so that their outside (negative) terminals pass through the holes in the smaller terminal plate. This plate is permanently connected to the remaining wires of the large terminal board.

(12) Connect the BA-23 batteries in series with the wires on the small terminal plate.

(13) Check battery connections at the 6- and 135-voltmeter readings. Check all connections for tightness and proper insulation. Make sure no loose wires interfere with the closing of the tray, figure 3-6.

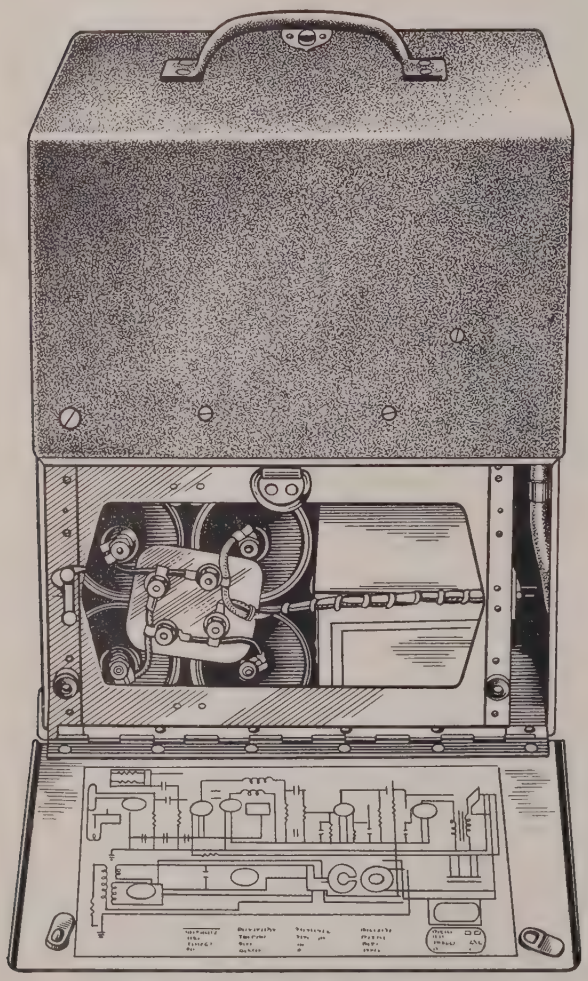


Fig. 3-7. Batteries in Position—Tray in Compartment.

(14) Close the tray, lock the hooks, and place in the same compartment with the ring facing outward. Close the door and secure it with the catches, figure 3-7.

c. INSTALLATION OF ANTENNA.—The antenna jack on the frequency meter panel will fit the male connector on the end of the long coaxial cable supplied, figure 3-8. An adapter is provided for any set using a female connector.

NOTE

For stronger signals, use the polythene probe.

CAUTION

Never couple the antenna directly to a transmitter.

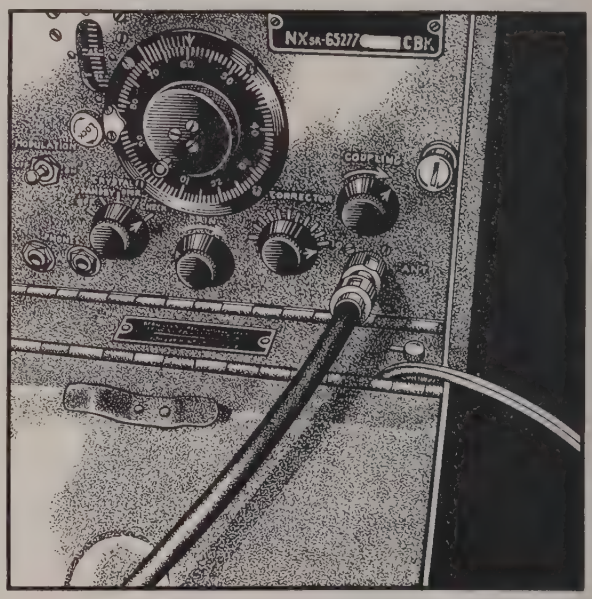


Fig. 3-8. Antenna Plugged into Antenna Jack.

2. OPERATION.

a. CORRECTING THE FREQUENCY METER TO CALIBRATION.

(1) Turn the SELECTOR switch to the STANDBY position and allow the set to warm up for at least 20 minutes.

(2) Put on the headset.

(3) Turn the SELECTOR switch to the CHECK position, figure 3-9A.

(4) Open the calibration book to the page listing the desired frequency. At the bottom of this page, the nearest crystal check point is printed in red and the associated dial setting appears in black.

(5) Set the main tuning dial, figure 3-9B, at the nearest crystal check point as indicated in the calibration book, (4) above. See sub-paragraph *c*(3) below for reading vernier.

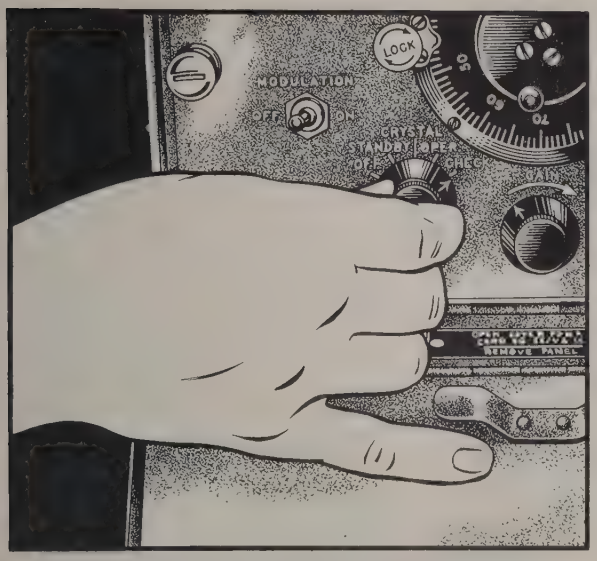


Fig. 3-9A. Turning to Check.

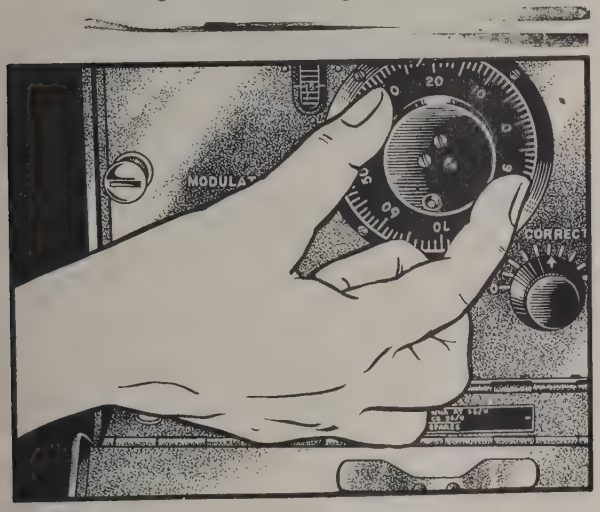


Fig. 3-9B. Setting Tuning Dial.

(6) Rotate the GAIN control clockwise as far as possible.

(7) Turn the CORRECTOR, figure 3-9C, control until a zero beat is obtained.

(8) To vary strength of signal input or output, adjust COUPLING control, figure 3-9D.

b. ZERO BEAT.—When two signals of different frequencies are combined in a mixer circuit, a third frequency is present in the output and is referred to as the beat frequency or beat note. This beat note is equal, numerically, to the difference between the two incoming signals. If these are only a few thousand cycles apart, the beat note will be heard in the headset. If the difference between the two incoming frequencies is gradually made smaller, the beat note will decrease in pitch. When the two original frequencies are identical, no note is heard. This point which is zero cycles per second is called zero beat. Since tuning is accomplished by the CORRECTOR, turning the CORRECTOR to the right or to the left of the zero beat position produces an audio note.

CAUTION

When the CORRECTOR is set for zero beat, it should be left at this position during the remainder of the operation.

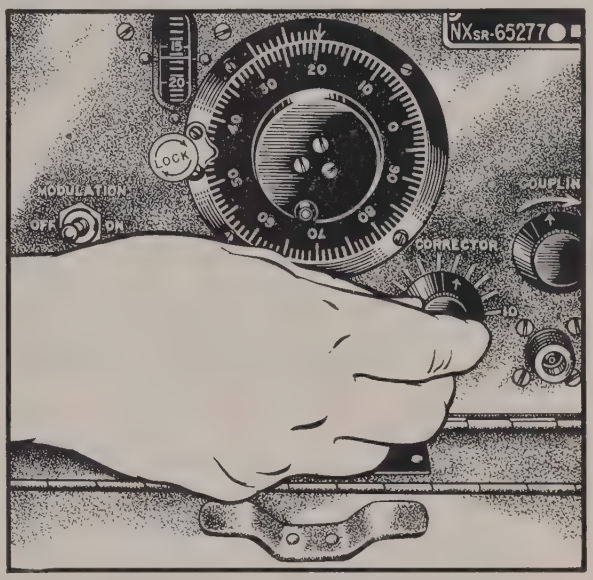


Fig. 3-9C. Adjusting Corrector.

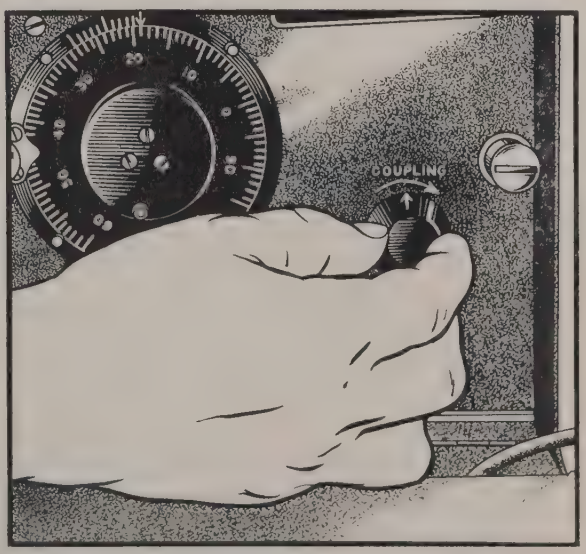


Fig. 3-9D. Adjusting Coupling Control.

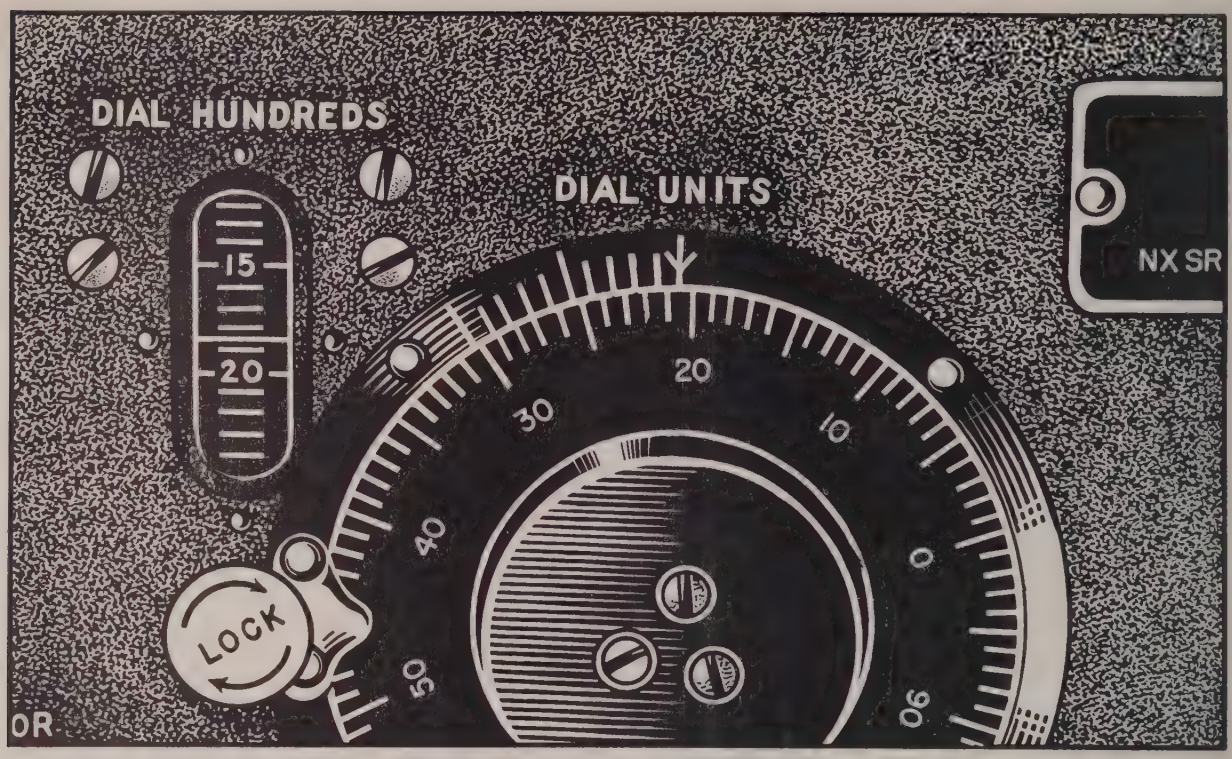


Fig. 3-10. Illustrating Vernier Setting.

c. INSTRUCTIONS FOR READING MAIN TUNING DIAL.

(1) Adjustment of the main tuning capacitor C1 is indicated directly by reading the DIAL HUNDREDS control. The light line will fall between two numbers, read the smaller.

(2) One complete revolution of the DIAL UNITS control advances the DIAL HUNDREDS control one division.

(3) A vernier scale, figure 3-10, accurately subdivides into tenths each division on the DIAL UNITS control. To read the vernier, observe which graduation on the vernier scale aligns with a graduation on the DIAL UNITS scale. Starting with the arrow as zero, count over to this graduation. The resulting number expresses, in tenths, the fraction of a DIAL UNITS division.

(4) For example, in figure 3-10, the setting is as follows:

DIAL HUNDREDS	1800.0
DIAL UNITS	20.0
VERNIER	0.7
CORRECT READING	1820.7

d. USE OF THE CALIBRATION BOOK.

(1) FINDING THE MAIN TUNING DIAL SETTING FOR A GIVEN FREQUENCY.

(a) Open the calibration book to the page listing the main tuning dial settings for a particular frequency. Use the index of frequencies to locate the correct page.

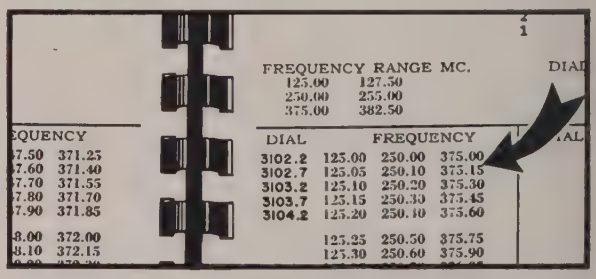


Fig. 3-11. Calibration Book—Example.

(b) Look down the proper right-hand column until the desired frequency is found. Look along the same line to the left to find the corresponding correct dial setting.

(2) FINDING THE FREQUENCY FOR A GIVEN MAIN TUNING DIAL SETTING.

(a) Open the calibration book to the page listing the main tuning dial settings. Use the index of dial settings to locate the correct page.

(b) Look down the left-hand column until the nearest desired setting is found. Look along the same line to find the corresponding frequency, figure 3-11.

(3) DETERMINING INTERMEDIATE VALUES BETWEEN LISTED FREQUENCIES (INTERPOLATION).—It is often necessary to find a frequency or a dial setting which falls between two values as given in the calibration book. The error introduced by merely using the nearest frequency will not exceed .0125 percent at the low end of the band or .025 percent at the high end of the band. For further accuracy, a midpoint reading between the two listed settings may be used. However, the method used for greatest accuracy is known as interpolation. The following example demonstrates how this is done. Suppose a dial setting is determined to be 3102.6, we are to find the corresponding frequency. Open the calibration book to the two dial settings nearest this number and write down the corresponding frequencies in a table, thus:

Dial Settings		Corresponding frequencies in megacycles	
3102.2	diff. = .4	125.00	diff. = .05
3102.6	diff. = .5	unknown	
3102.7		125.05	

The frequency increase for .5 dial division is .05 megacycle or .05 ÷ .5 = .1 megacycle per division. The frequency we are trying to determine is found at a dial setting .4 divisions above 125 megacycles.

So, .1 megacycle/division x .4 division = .04 megacycles.

The unknown frequency is therefore 125.04 megacycles.

To determine a dial setting if an unlisted frequency is known, the unknown value is placed in the other column but the general process is the same. For instance in the above example, if the dial setting corresponding to 125.02 is to be found, proceed as follows:

Dial Settings		Corresponding Frequencies in Megacycles	
3102.2	diff. = .5	125.00	diff. = .05
unknown		125.02	
3102.7		125.05	

As before, the frequency increases .1 megacycles per division. The dial setting wanted corresponds to .02 megacycles above 3102.2 so,

$$\frac{.02 \text{ megacycles}}{.1 \text{ megacycle/division}} = .2 \text{ divisions}$$

The unknown setting is therefore 3102.2 + .2 = 3102.4

e. TUNING A TRANSMITTER TO A DESIRED FREQUENCY (APPROXIMATE TRANSMITTER FREQUENCY KNOWN).—Tuning a transmitter to a desired frequency value is done by zero beating the transmitter signal with the proper heterodyne oscillator signal. This is accomplished as follows:

NOTE

If the approximate transmitter frequency is not known, follow the procedure given in sub-paragraph *j* below to determine the frequency.

(1) Correct the heterodyne oscillator to calibration at the crystal check point nearest the desired frequency.

(2) Turn the SELECTOR switch to the OPERATE position.

(3) From the calibration book, determine the dial setting for the desired frequency.

(4) Turn the main tuning dial to the correct setting, then lock the dial.

(5) Loosely couple the frequency meter antenna to the transmitter output. This is done by inserting the antenna probe into the transmitter chassis; the coupling control is used for attenuation of the signal. Tune the transmitter until an audible sound is heard in the headset. Rotate the GAIN control fully clockwise if necessary.

(6) Tune the transmitter control to zero-beat with the frequency meter.

(7) The transmitter is now radiating at the same frequency as the frequency meter.

f. MEASURING THE FREQUENCY OF A LOCAL TRANSMITTER (APPROXIMATE FREQUENCY KNOWN).

(1) Correct the heterodyne oscillator to calibration at the crystal check point nearest the desired frequency.

(2) Turn the SELECTOR switch to the OPERATE position.

(3) Loosely couple the meter to the transmitter. Turn the main tuning dial to either side of the supposed frequency at the transmitter and obtain a zero beat at the unknown frequency.

(4) Open the calibration book to the dial setting and read the corresponding frequency.

g. TUNING A C-W RECEIVER TO A DESIRED FREQUENCY.

(1) Correct the heterodyne oscillator to calibration at the crystal check point nearest the desired frequency.

(2) Turn the SELECTOR switch to the OPERATE position.

(3) Place the main tuning dial on the correct setting for the desired frequency. Obtain this setting from the calibration book, interpolating if necessary.

(4) Connect a headset or loudspeaker to the output of the radio receiver.

(5) Couple the frequency meter antenna cable to the radio receiver and tune the receiver to produce an audible tone.

(6) Adjust the tuning control of the radio receiver to a zero beat.

NOTE

If the receiver has a beat oscillator, turn it on and tune the signal from the frequency meter to zero beat. If the receiver is of the regenerative type, advance the regenerative control until the detector starts to oscillate. In this condition, the receiver will respond to C-W signals and may be set to a frequency in the same manner as a receiver having a beat oscillator.

h. TUNING A RECEIVER TO A DESIRED FREQUENCY WHEN RECEIVER HAS NO MEANS OF PRODUCING A BEAT NOTE.

(1) Correct the heterodyne oscillator to calibration at the crystal check point nearest the desired frequency.

(2) Set the main tuning dial at the desired frequency and the SELECTOR switch at OPERATE.

(3) Throw the MODULATION switch to the ON position.

(4) Couple the frequency meter antenna to the receiver. Direct coupling may be used if COUPLING control is adjusted.

(5) Tune the receiver to the greatest output audible in the receiver headset.

i. MEASURING THE FREQUENCY OF A DISTANT TRANSMITTER.—This procedure requires the use of a radio receiver in conjunction with the frequency meter.

(1) Tune in the signal from the distant transmitter on the radio receiver. Determine the approximate frequency from the dial setting.

NOTE

If it is a C-W transmitter, use either a receiver with a beat oscillator or a regenerative type receiver. Turn on the beat oscillator or turn up the regeneration control until the receiver oscillates. Tune the receiver to zero beat.

(2) Turn the beat oscillator off or adjust the regenerative receiver to a non-oscillating condition before proceeding.

(3) Correct the frequency meter to calibration at the crystal check point nearest the approximate frequency indicated by the receiver dial.

(4) Set the SELECTOR switch to OPERATE.

(5) Loosely couple the frequency meter to the receiver antenna lead. Plug the headset into the receiver output phone jack. Now turn the main tuning dial of the frequency meter in the region of the approximate frequency until a beat note is heard between the transmitter signal and the signal from the frequency meter.

NOTE

It may be necessary to vary the coupling between the meter and the receiver to obtain a satisfactory beat note. This is done by turning the COUPLING control until a distinct beat note is heard.

j. MEASURING THE FREQUENCY OF A TRANSMITTER (APPROXIMATE FREQUENCY UNKNOWN).

(1) Determine the approximate frequency with an absorption-type wavemeter, then follow the procedure described in sub-paragraph *f*.

(2) If an absorption-type wavemeter is not available, use the following method:

(a) Correct the heterodyne oscillator to calibration at the 180-megacycle crystal check point.

(b) Turn the main tuning dial from the low to the high end, listening carefully for beat notes.

(c) More than one loud beat note should be heard. This indicates that consecutive harmonics of the heterodyne oscillator signal are beating with the signal of unknown frequency; i.e., if the unknown signal frequency were 360 megacycles, consecutive harmonic beat notes would be obtained at the 4th harmonic of 90 megacycles, the third harmonic of 120 megacycles, and the second harmonic of 180 megacycles. After determining roughly a series of beat points, check the calibration of each point, interpolating when necessary if greatest accuracy is desired.

(d) Using two adjacent zero beat points, apply the following equation:

$$F_x = \frac{F_l \times F_h}{F_h - F_l}$$

F_x equals the unknown frequency, F_l equals the lower consecutive harmonic, and F_h equals the higher consecutive harmonic. In the formula, use only the fundamental frequency found in the second column. For example, suppose two such adjacent zero-beat points are obtainable at 105 megacycles and 140 megacycles, then:

$$F_h - F_l = 140 - 105 = 35$$
$$F_h \times F_l = 14700$$
$$F_x = \frac{14700}{35} = 420 \text{ megacycles}$$

This formula is only practical in the range from 180 to 450 megacycles. If the unknown signal is in the range from 90 to 180 megacycles, only one beat note will be heard.

CAUTION

Use only signals of relatively equal intensities.

k. MEASURING THE FREQUENCY TO WHICH A RECEIVER IS TUNED.

(1) Correct the heterodyne oscillator to calibration at a crystal check point near the approximate frequency at which the receiver is tuned.

(2) Place the SELECTOR switch in the OPERATE position.

(3) Couple the frequency meter to the receiver.

(4) If the receiver has a beat frequency oscillator, turn it ON. Then turn the main tuning dial of the frequency meter to a position near the approximate frequency at which maximum audio output is obtained from the receiver under test. At the same time, vary the frequency of the C-W oscillator in the receiver to keep the audio output at some convenient frequency.

(5) Read the main tuning dial of the frequency meter and look up the corresponding frequency in the calibration book.

(6) If the receiver has no local C-W oscillator, turn the MODULATION switch to the ON position and set the receiver for maximum audio output.

FAILURE REPORTS

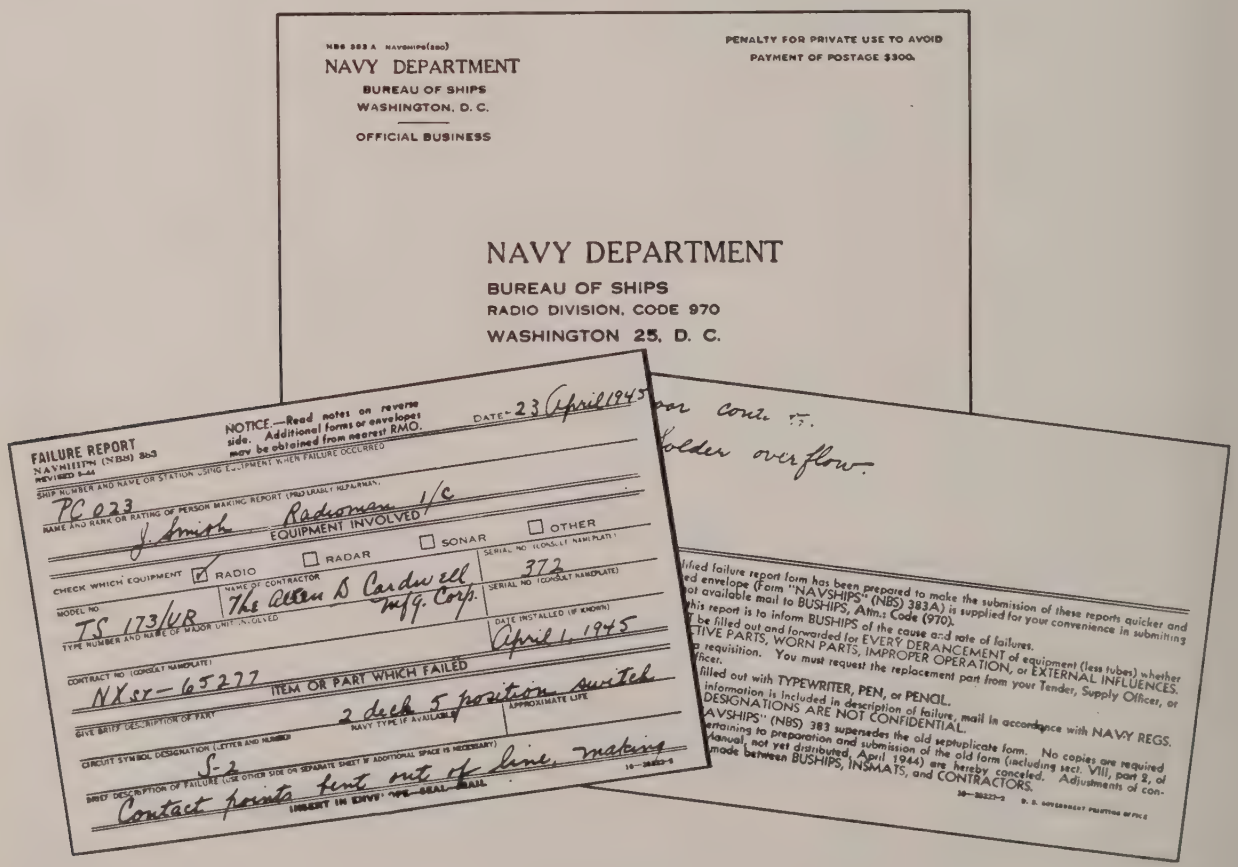
A failure report must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report, form NBS-383 (Revised), which has been designed to simplify this requirement. The card must be filled out and forwarded to BUSHIPS in the franked envelope which is provided. Full instructions are to be found on each card.

Use great care in filling the card out to make certain it carries adequate information. For example, under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T-803, in the case of a transformer, or R-207, for a resistor. Do not substitute brevity for clarity. Use the back of the card to completely describe the cause of failure and attach an extra piece of paper if necessary.

The purpose of this report is to inform BUSHIPS of the cause and rate of failures. The information is used by the Bureau in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The cards you send in, together with those from hundreds of other ships, furnish a store of information permitting the Bureau to keep in touch with the performance of the equipment of your ship and all other ships of the Navy.

This report is not a requisition. You must request the replacement of parts through your Officer-in-Charge in the usual manner.

Make certain you have a supply of Failure Report cards and envelopes on board. They may be obtained from any RMO.



SECTION 4 — MAINTENANCE

1. SIMPLE TROUBLE SHOOTING PROCEDURE FOR OPERATING PERSONNEL.

a. GENERAL. — When meter operation is defective operating personnel may make only the following tests. Remember TS-173/UR is a precision instrument.

(1) *Check all controls to make sure each is in proper position.* For instance, if the SELECTOR switch is at CHECK and no sound is heard, the MODULATION switch may have been left in the ON position.

(2) Check fuse.

(3) Check battery voltages, see sub-paragraph *b* below.

(4) Check headset and cord for continuity of circuit between the tip and the sleeve of the headset plug with a continuity meter or an ohmmeter. If no such meter is available, open the power supply compartment of the frequency meter and touch the tip of the headset plug to one A-terminal while the sleeve is in contact with the other terminal. A distinct AC hum should be heard.

(5) If controls are in proper position, remove the meter by turning the two Dzus fasteners, figure 4-1, near the sides of the panel and pulling outward gently. Push all tubes firmly into their sockets. Feel each tube with bare hands after allowing meter to warm up for five minutes. Replace from spare parts compartment or from general stock any tube which feels colder than the others. Use tube of same manufacturer if possible.

(6) Replace tubes one at a time until meter operates or until all tubes have been replaced. Return good tubes to sockets. Check visually for loose or broken wires, burned out resistors, loose tube connections, etc. Remove oscillator section cover plate and tuning capacitor section cover plate. Inspect for metallic slivers, poor connections, burned out resistors, etc. Metallic slivers may be blown out with a compressed air jet. DO NOT FORCE APART INDUCTOR TURNS OR CAPACITOR PLATES. MAKE SURE COVER PLATES ARE FIRMLY SCREWED BACK IN PLACE.

NOTE

Use all tubes of a given type supplied with the equipment before using tubes from the general stock, figure 3-1.

b. BATTERY CHECK. — During normal service, if the set is using batteries, the battery voltages should be checked weekly and after idle periods of more than one week.

(1) Turn the OPERATE switch to CRYSTAL and allow a minute or so for warming up.

(2) Open power supply compartment to expose battery terminal strip, figure 4-2.

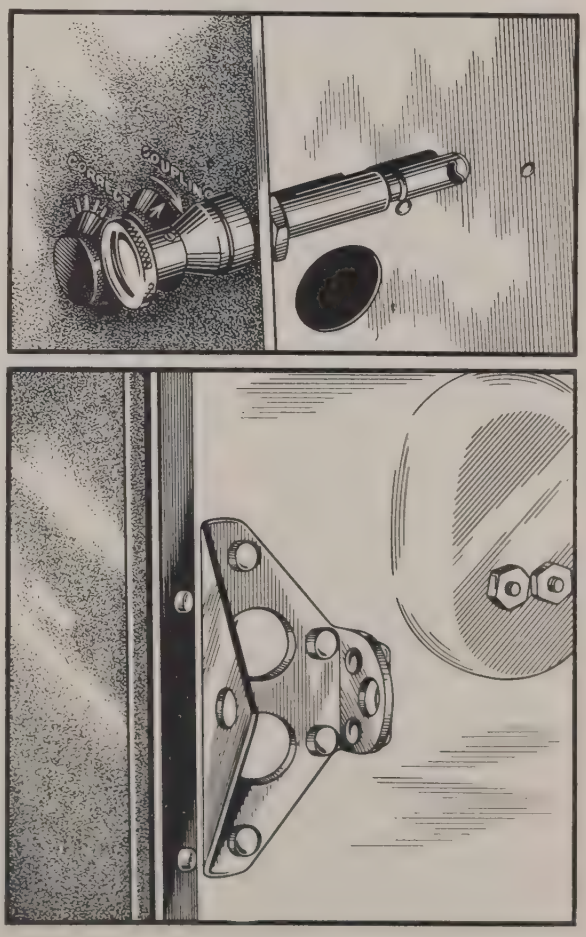


Fig. 4-1. Dzus Fastener and Bracket.

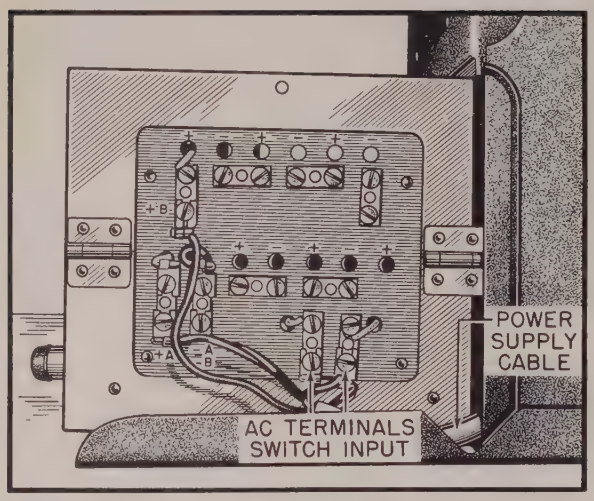


Fig. 4-2. Terminal Panel of Power Supply.

(3) Measure the B voltage between B+ and A–, B– terminals. Use a 1000 ohm-per-volt voltmeter Navy Model OCR or equivalent with full scale range of at least 150 volts. If this reading is less than 120 volts, replace batteries BA-2.

(4) Measure the A voltage between the A+ and A–, B– terminals. Use a 1000 ohms-per-volt voltmeter Navy Model OCR or equivalent with full scale range of at least 6 volts. If this reading is less than 5.4 volts, replace batteries.

2. TROUBLE SHOOTING INSTRUCTIONS FOR MAINTENANCE PERSONNEL.

a. GENERAL.—Before attempting the following procedures for localization of troubles, be sure to perform the steps outlined in paragraph 1 of this section.

NOTE

These procedures are based on the use of voltmeter and ohmmeter measurements rather than signal tracing by oscillographic methods because of the high frequencies involved. A standard oscillograph may be used when checking the audio amplifier and modulator stages.

During trouble shooting, open this book to the trouble shooting chart, figure 4-3, while referring to the circuit schematic mounted on the rear door of the cabinet.

b. LOCALIZATION OF FAULTY CIRCUITS. (Figures 4-4, 4-6, 4-8, and 4-9*). — The preliminary examinations for position of controls, B+, filament voltages, poor tubes, etc. should be made first. Then, check the following:

(1) Heterodyne oscillator.
(2) Crystal oscillator.
(3) Mixer circuit.
(4) Amplifier.

(*a*) To check the operation of the heterodyne oscillator, put the meter into operation as outlined in Section 3, paragraph 2*g* (tuning a C-W receiver to a desired frequency). Couple a receiver to the antenna and listen for a beat note in the receiver headset. Absence of a detectable beat note will indicate that the heterodyne oscillator is not functioning, figure 4-4.

NOTE

The heterodyne oscillator section, figure 4-5, is furnished mounted on a Mycalex block and calibrated as a unit. If repairs other than a tube replacement are to be made, the entire block is to be disconnected and sent to the factory. See Table 5-2 (under C1) for Tuning Capacitor and Oscillator Coils Assembly recorder numbers.

(*b*) To determine whether the crystal oscillator is functioning, put the meter in operation as discussed in subparagraph (*a*) above, with the OPERATE switch on CRYSTAL. Failure to detect a beat note in the receiver headphones will indicate that the crystal oscillator is not operating, figure 4-4.

(*c*) If both oscillator circuits are oscillating, the fault may be in the mixer circuit. To test this circuit, it is necessary to remove the equipment from the cabinet and connect the plugs at the back of the cabinet to the jacks on the meter with long laboratory leads. Be sure to connect them in correct order. If batteries are being used, it may be desirable to use an entirely new set for testing purposes. Proceed as follows:

1. Be sure GAIN control is at MAXIMUM.
2. Place OPERATE switch at CHECK.
3. Pull the mixer 9001 out of its socket a few times. If a loud click is heard each time, the mixer circuit and amplifier circuits are operating. If not, refer to figure 4-3.

(*d*) With the OPERATE switch still at CHECK, check the amplifier stages by following figure 4-3. If an oscilloscope is available, a waveform should be obtainable at the grid of the 9001 by rotating the CORRECTOR control. If the output of this circuit is normal, a waveform will also be obtainable, amplified, at the plate; if not, check R11. In the second stage, a signal should be present on the grid of 9002 and on the plate. If no grid signal is present, check C18; if there is no plate signal, investigate the modulation switch and the winding of T1 (3-4) for continuity.

* Figure 4-9 is located on page 5-15.

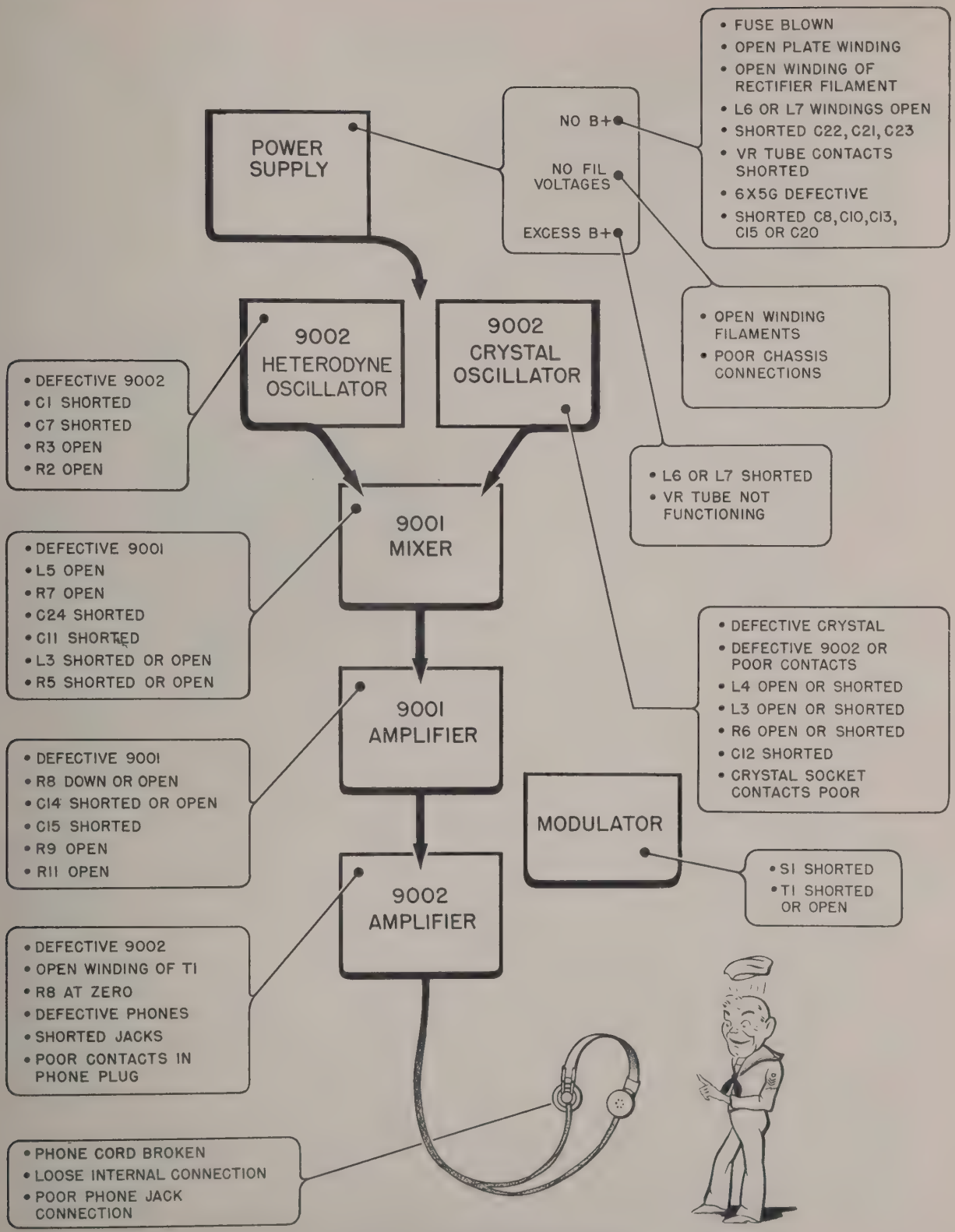


Fig. 4-3. Trouble Shooting Chart.

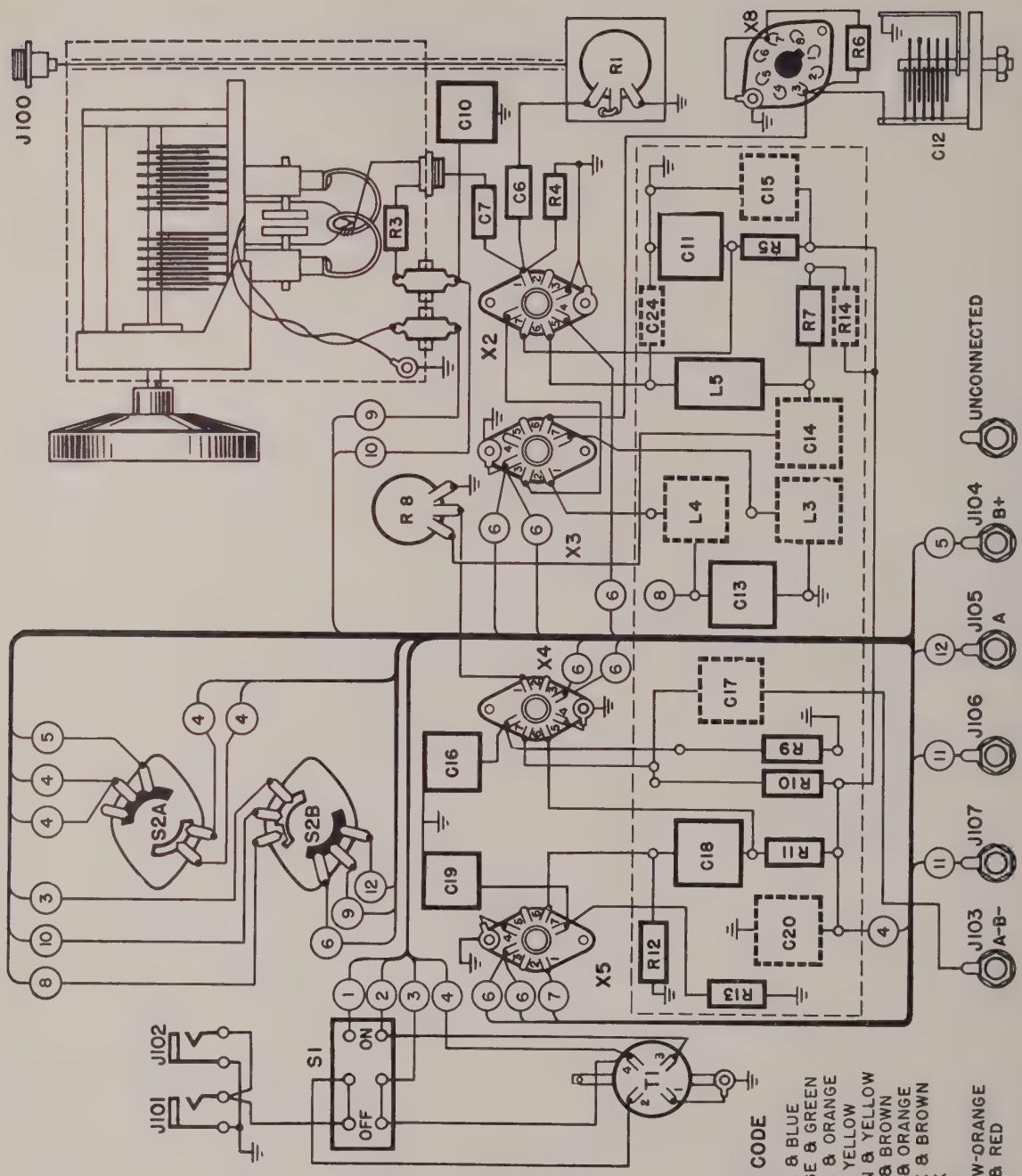


Fig. 4-4. Practical Chassis Wiring Diagram.

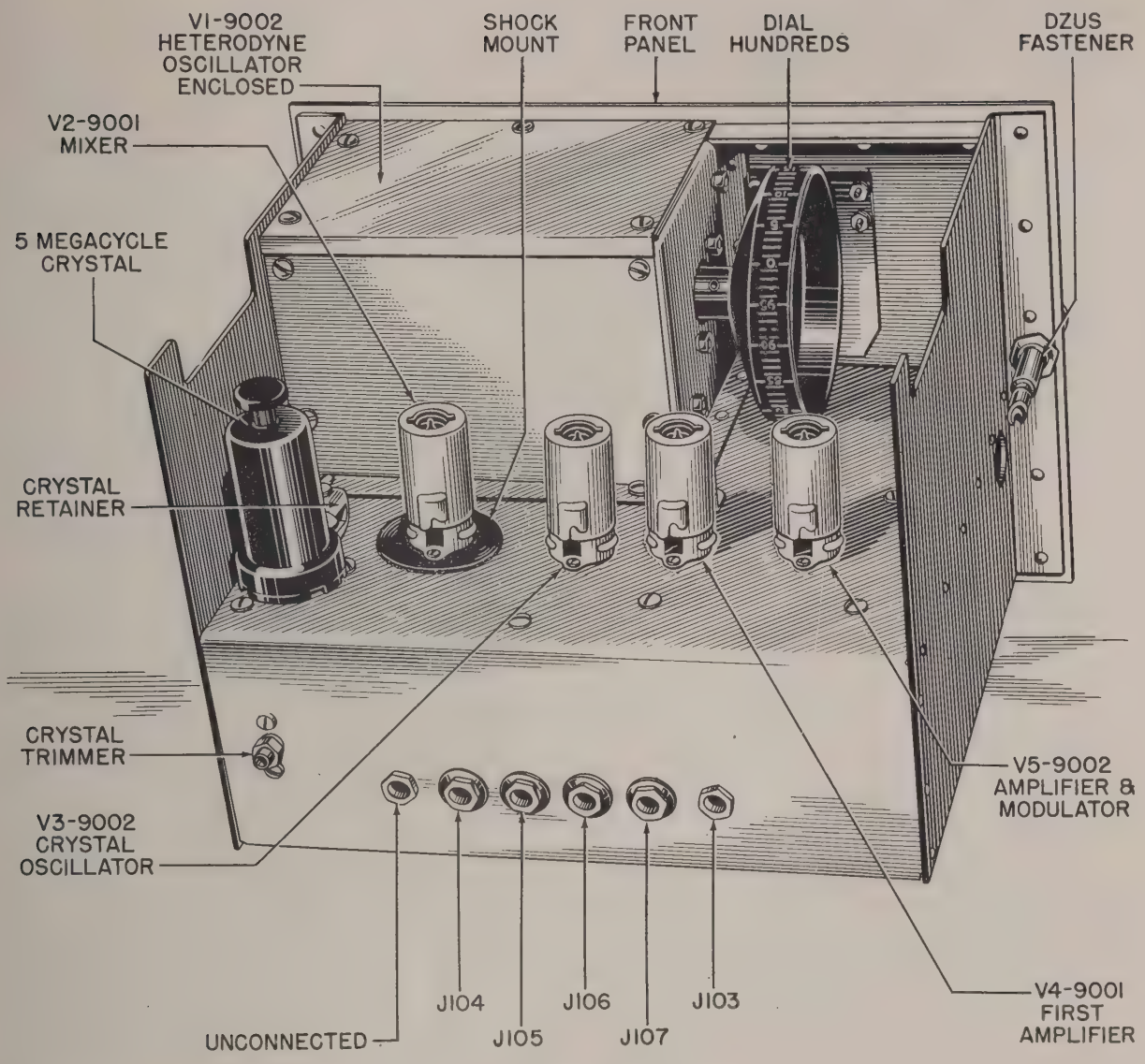


Fig. 4-5. Top Rear View of Chassis.

(*e*) To determine whether the modulating oscillator is functioning, turn it to the OPERATE position and turn switch S1 to the ON position. Take the headphone tips out of the jack and touch ONE TIP ONLY to terminal 3 of T1. A definite tone should be heard if the modulator is functioning. If not, check T1 and S1 contacts.

(*f*) Weak signals either in the headphones or transmitted by the meter are generally due to the attenuator or to a faulty antenna cable. To check the attenuator, measure the resistance across the entire attenuator. It should be continually variable from 0 to 2000 ohms. If this does not measure correctly, locate the particular resistor by measuring from the arm of each resistor to ground; the measurement for each should be variable from 0 to 1000 ohms. If the attenuator is in working order, replace the antenna cable with a new cable.

c. REPLACEMENT AND RECALIBRATION.

(1) When it becomes necessary to replace the heterodyne oscillator tube, the meter must be set for calibration. The procedure is as follows:

(*a*) With set OFF, unscrew bottom oscillator section plate and replace tube and plate. Be sure to screw plate down tightly. Connect set to banana plugs in back of cabinet with long leads.

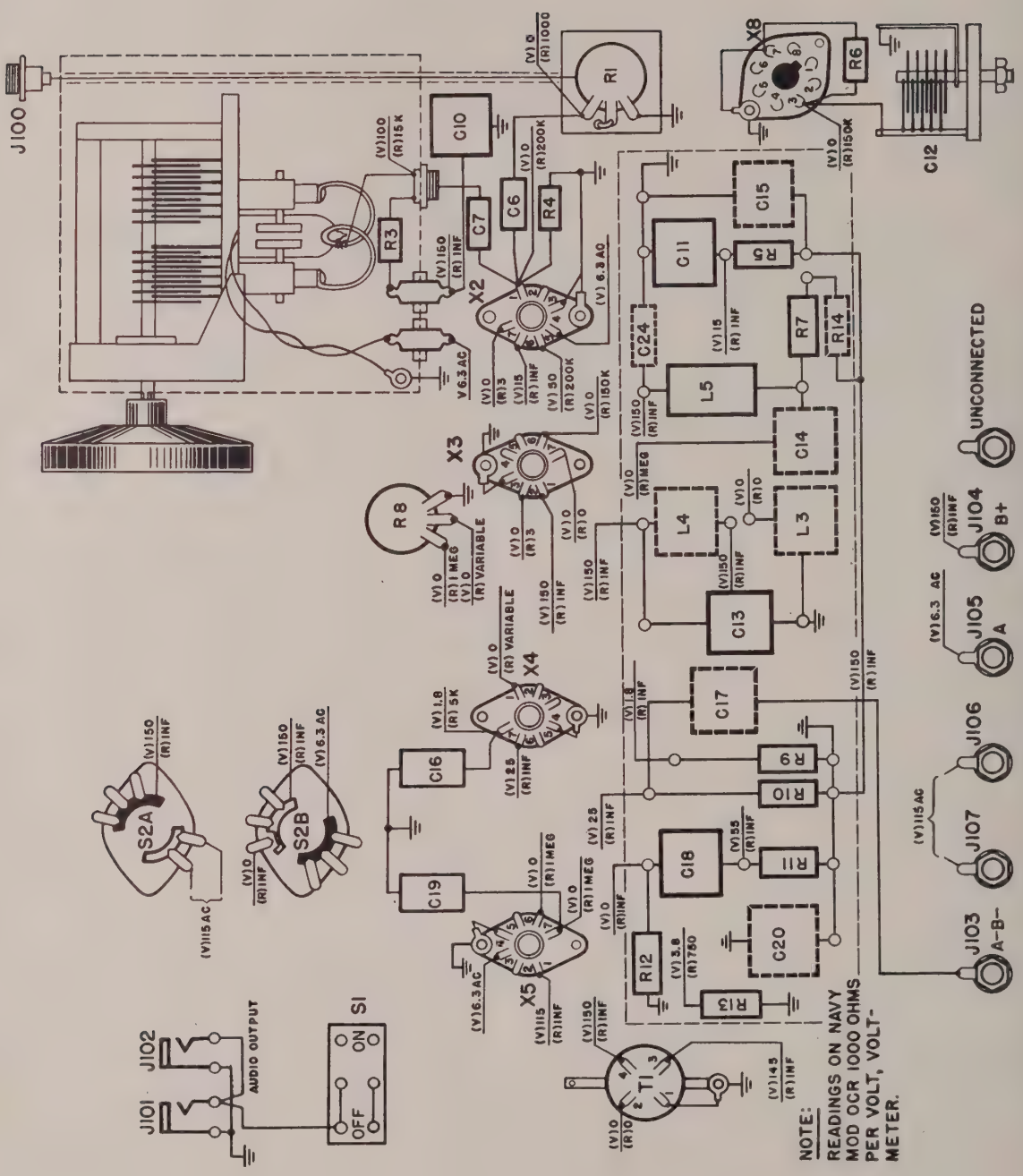


Fig. 4-6. Chassis Voltages and Resistances to Ground.

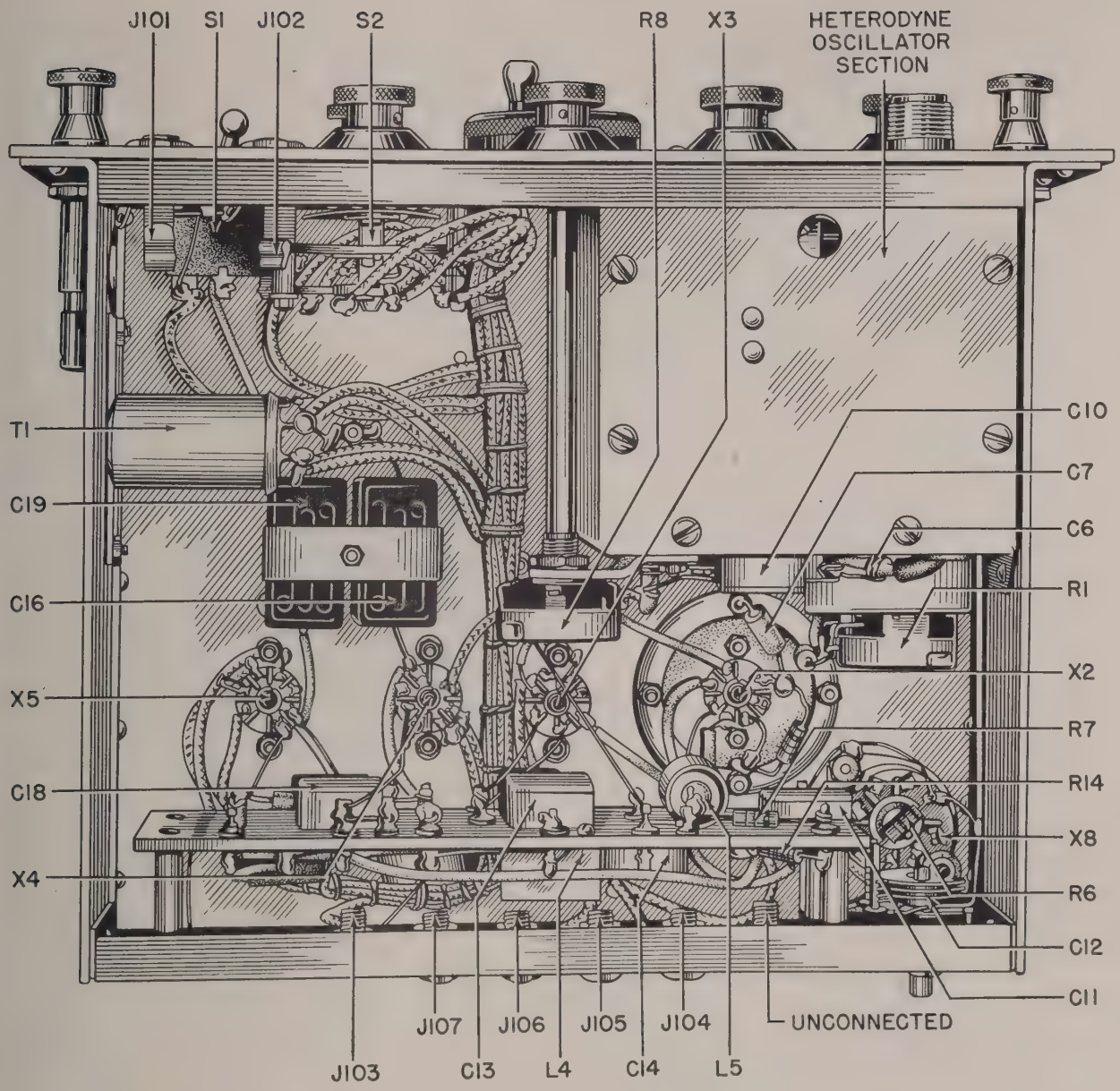


Fig. 4-7. Bottom View of Chassis.

(*b*) Rotate CORRECTOR knob on front panel to the FOURTH line on the 0—10 scale above the control knob and allow set to warm up.

(*c*) Refer to calibration book and set main tuning dial to published calibration point at 90 megacycles. Adjust corrector to zero beat.

(*d*) DO NOT TOUCH CORRECTOR. Set the main tuning dial to the calibration point at 180 megacycles. DO NOT TUNE TO ZERO BEAT.

(*e*) Using an insulated screwdriver or an aligning tool, adjust C3 (oscillator trimmer) to zero beat at 180 megacycles. This operation is delicate and requires patience and practice since zero beat must be obtained when the screwdriver is AWAY from C3. Adjustment is made by loosening the setscrew of C3 and moving the plate back and forth. When the operation is finished, the setscrew must be tightened.

(*f*) Now rotate MAIN TUNING DIAL slowly back to the 90-megacycle check point, counting the number of beat notes passed. There should be 19 of

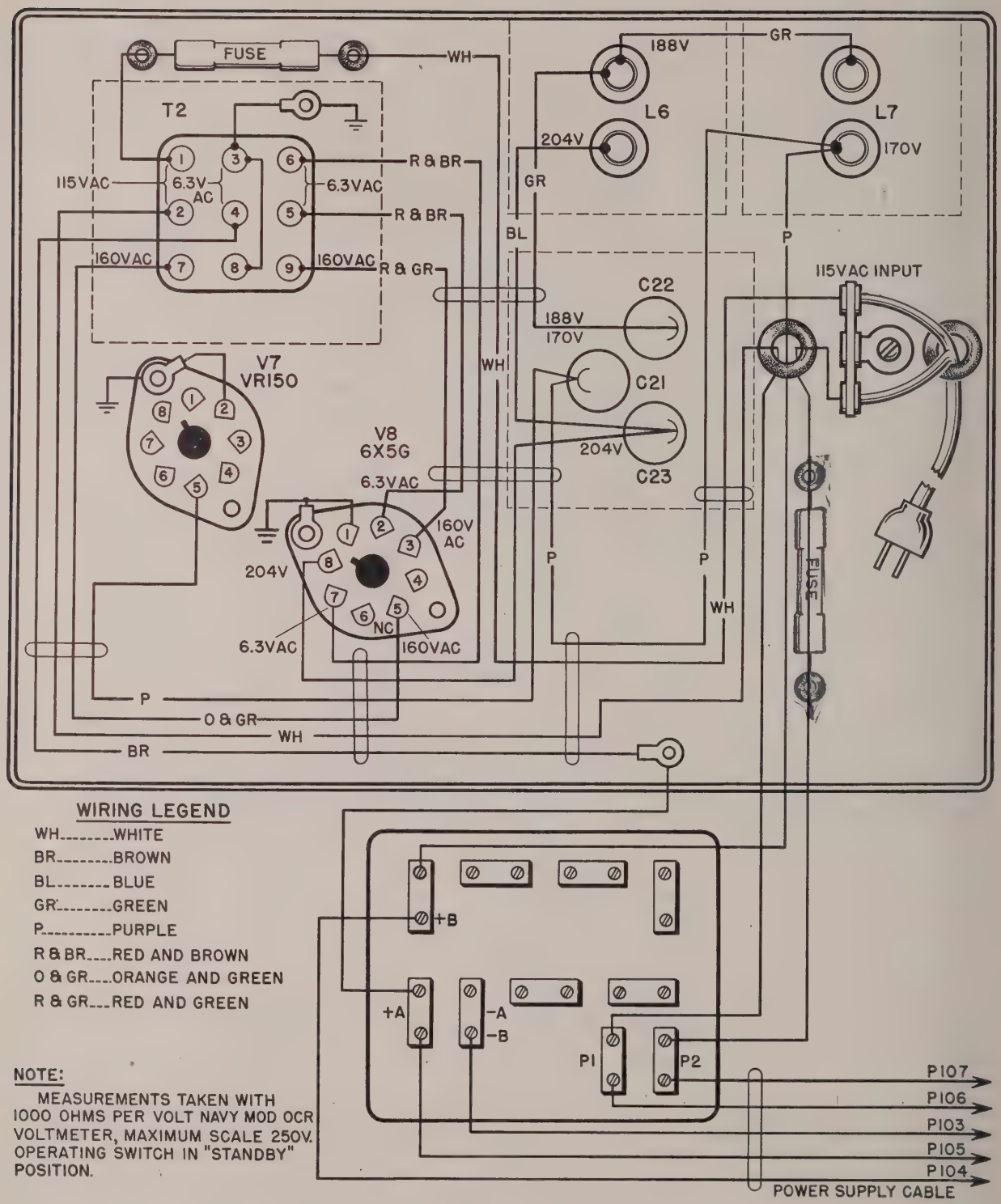


Fig. 4-8. Practical Power Supply Wiring Diagram.

these. Use the corrector to obtain a beat note at 90 megacycles.

(*g*) Return to the 180-megacycle point and retrim C3 if necessary. Repeat this series of operations three times.

(*h*) When satisfied that the set is in calibration, make sure C3 is locked with the setscrew before returning meter to cabinet.

(*i*) After replacing the crystal, the meter calibration should be checked. If it is necessary to tune the crystal oscillator to five megacycles, the procedure is as follows:

1. Replace meter in cabinet.

2. Tune any suitable receiver to station WWV, which is the Bureau of Standards at either five, ten, or fifteen megacycles.

3. Turn the operating switch to CRYSTAL and couple the meter antenna to the receiver antenna. A slow flutter should be heard in the receiver headphone if no adjustment is necessary. If adjustment must be made, unscrew cap in rear of cabinet and tune to zero beat in the receiver phones by adjusting C12, figure 4-7, with socket wrench. KEEP RECEIVER TUNING DIAL AT FIVE MEGACYCLES WHILE ADJUSTING C12.

4. If it is necessary to modulate the crystal output to distinguish a zero beat more accurately, turn the MODULATION switch to the ON position.

TABLE 5-1

LIST OF MAJOR UNITS

QUANTITY	NAME OF MAJOR UNIT	NAVY TYPE DESIGNATION	SYMBOL GROUP
1	Frequency Meter	TS-173/UR	1-200

TABLE 5-2

COMBINED PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATION FOR NAVY TYPE TS-173/UR

PARTS										SPARE PARTS					
										EQUIP.		TENDER		STOCK	
SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN, OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRACTOR'S DWG. AND PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED	TOTAL NO. PER EQUIP.	Box No.	Quan.	Box No.	Quan.	Box No.	Quan.
A101	MOUNT, vibration: circular; designed to support 7-prong ceramic socket on rubber diaphragm; 2″ diam x 1″ h; top bakelite plate mounted on ceramic socket; supports bakelite tube retainer.	Prevents mixer tube microphonics						A101	1		1		1		1
C1	TUNING CAPACITOR AND OSC COILS ASSEMBLY: mounted on Mycalex block, 2″ wd x 3″ lg x 1/4″ thk; enclosed in aluminum box with removable plates on top and bottom.	Heterodyne oscillator				Cardwell A4.425	See mfr.	C1, C2, C3, C4, C5, R2, L1, L2	1		0		0		0
C6	CAPACITOR, fixed: ceramic; 6 mmf ± 10%; 500 vdcw; zero temp. coeff; 7/16″ lg x 7/32″ diam.	Antenna capacitor	JAN-C-20 type CC 21CF060K		3D9006-5	Erie NPOK6	4.443	C5, C6, C7	2		1		1		2

C7	Same as C6	RF coupling cap	JAN–C–20 type CC 21CF060K	3D9006–5								
C8	CAPACITOR, fixed: ceramic; 55 mmf ± 10%; minus 75 mmf/mf/°C; 500 vdcw; 5/8" lg x 1/8" diam.	Heterodyne osc 9002 plate feed through		3D9055–6	Erie 357–000	10.041	C8, C9	2	2	4	4	
C9	Same as C8	Heterodyne osc 9002 fil feed through		3D9055–6								
C10	CAPACITOR, fixed: mica; 3900 mmf ± 10%; 500 vdcw; 53/64" lg x 53/64" wd x 11/32" thk.	Plate bypass cap	JAN–C–5 type CM 35B392K	3K3539221	Micamold	8.033	C10, C13	2	1	2	2	
C11	CAPACITOR, fixed: 2000 mmfd ± 10%; 500 vdcw; 3/4" lg x 3/4" wd x 1/4" thk.	Mix 9001 screen bypass	JAN–C–5 type CM 30B202M	3DA2–73	Cornell-Dubilier IWLN–5D2	6.012	C11, C15	2	1	2	2	
C12	CAPACITOR, variable: ceramic; 3.4 — 36 mmf; 5 stator and 5 rotor plate.	Crystal trimmer			Sickles ARL–18		C12					
C13	Same as C10	Plate bypass capacitor	JAN–C–5 type CM 35B39ZK	3K3539221								
C14	CAPACITOR, fixed: mica; 6800 mmf ± 10%; 300 vdcw; 53/64" lg x 53/64" wd x 9/32" thk.	Audio coupling capacitor	JAN type CM 35B68ZK	3K3568221	Cornell-Dubilier IWL	3.286	C14, C18	2	1	2	2	
C15	CAPACITOR, fixed: paper; 100,000 mmf ± 20%; 400 vdcw; 1 13/32" lg x 3/4" wd x 3/8" thk	Amp 9001 cathode cap	AWSC75/ 221 type CN 41B104	3DA100–112.1	Solar MPW–5147A	3.284 dwg WF–1306	C15, C16, C17, C19, C20	4	2	6	10	
C16	Same as C15	Mix 9001 plate bypass	AWSC75/ 221 type CN 41B104	3DA100–112.1								
C17	Same as C15	Amp 9001 screen cap	AWSC75/ 221 type CN 41B104	3DA100–112.1								

TABLE 5-2

COMBINED PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATION — (Continued)

FOR NAVY TYPE TS-173/UR

PARTS										SPARE PARTS					
										EQUIP.		TENDER		STOCK	
SYM-BOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN, OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRAC-TOR'S DWG. AND PART NO.	ALL SYMBOL DESIG-NATIONS IN-VOLVED	TOTAL NO. PER EQUIP.	Box No.	Quan.	Box No.	Quan.	Box No.	Quan.
C18	Same as C14	Audio coupling cap	JAN type CM 35B682K		3K3568221										
C19	Same as C15	Amp 9002 cathode cap	AWS C75/221 type CN41B104		3DA100–11 2.1										
C20	Same as C15	B + bypass filter	AWS C75/221 type CN41B104		3DA100–112.1										
C21	CAPACITOR, fixed: paper; 3-section; 4–4–8 mf; 400 vdcw; 2 3/8″ wd 2 5/8″ lg 4 1/8″ h; hermetically sealed; castor oil impregnated; specially manufactured under JAN–C–25 specs.	Power supply filter cap				Electrical utilities 10953	10.068 dwg 173–DW	C21, C22, C23	1		1		2		2
C22	Same as C21	Power supply filter cap													
C23	Same as C21	Power supply filter cap													
C24	CAPACITOR, fixed: mica; 50 mmf ± 5% 500 vdcw; 1 1/16″ lg x 7/16″ wd x 3/16″ thk.	RF filter	JAN type CM3513500 J		3K35500221	Cornell Dubilier 5N505	7.010	C24	1		1		2		2

E101 (Antenna Assem)	ANTENNA: AT-66/U; coaxial; flexible; 9 5/8" lg; made of Army-Navy RF cable RG-B/U but less outer covering and shield for 6 5/8" at outer end; w/term as follows: Astatic CQA-49298 on one end.	Antenna	Army-Navy No. AT-66/U	3F3988/66	Cardwell	A3.300 dwg WF-A-1400	E101	1	0	0	2
E102 (Cable Assem)	CABLE ASSEMBLY, RF: coaxial; flexible; 4' 10 1/2" lg ; Army-Navy RF cable RG-8/U w/term as follows: Astatic CQA-49268 on both ends.	For connection to RF terminal of a receiver	Army-Navy No. CG 55/U	1F430-55	Cardwell	A3.302 dwg WF-A-1402	E102	1	0	0	2
E103 (Cable Assem)	CABLE ASSEMBLY, RF: coaxial; flexible; 4 5/8" lg; Army-Navy RF cable RG-8/U w/ term as follows: Astatic CQA-49298 on one end, CQA-49190 on other.	Adapter for connection to different type of coaxial cable connector.	Army-Navy No. CG 56/U	1F430-56	Cardwell	A3.301 dwg WF-A-1401	E103	1	0	0	2
E104	POWER CORD										
E105	KNOB, control: blackened aluminum; diam shaft 1/4"; two No. 6-32 set screws at 90° angle; arrow marking; 5/8" lg x 1 1/8" diam.	Control knob			Cardwell	3.411 dwg 173-BL	E105	4	0	0	4
E106	HOLDER, fuse: block type; for single 3 AG fuse; 1/8" bakelite base with phos bronze clips; 250 v, 1 amp max; 2 1/8" lg x 1/2" w x 5/8" h.	Fuse mount			Bussmann 3AG4495	10.063	E106	1	1	1	1
F1	FUSE, glass enclosed: 1 amp; 250 v; one-time; glass; 1 1/4" lg x 1/4" diam.	Fuse	28032-1	3Z1926 (FU-26)	Littlefuse 3AG1040	10.064	F1	1	20	40	100

TABLE 5-2
COMBINED PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATION — (Continued)
FOR NAVY TYPE TS-173/UR

PARTS										SPARE PARTS					
										EQUIP.		TENDER		STOCK	
SYM-BOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN. OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRAC-TOR'S DWG. AND PART NO.	ALL SYMBOL DESIG-NATIONS IN-VOLVED	TOTAL NO. PER EQUIP.	Box No.	Quan.	Box No.	Quan.	Box No.	Quan.
H101 (Bristo wrench)	WRENCH, setscrew: 1¾″ lg x 9/16″ wd; 4 spline shaft for No. 6–32 setscrew.					Bristol Co.	1.113	H101	1		1		1		1
H102	RING, "D" and support: brass, nickel finish; 1½″ h x 13/16″ wd x ¼″ thk.	Anchorage for carrying strap				Cardwell	A1. 181 dwg WF–A1133	H102	3		0		0		3
H103	CLAMP, tube: phos-phor bronze, nickel plated; one bolt, fits 1⅛″ tube base.	Secures JAN/ OD3/VR-150/ 30 to power supply chassis.				Birtcher	10.062 dwg 926A	H103	1		0		0		1
H104	CLAMP, tube: phos-phor bronze, nickel plated; one bolt; fits 1¼″ tube base.	Secures JAN 6X5G to power supply chassis.				Birtcher	10.073 dwg 926B	H104							
H105	CLAMP, cable: brass, nickel plate; 1 bolt; 15/16″ lg x ⅜″ wd x ½″ h.	Clamps power supply output cable to case wall.				Cardwell	2.026 dwg 1–898	H105, H106	2		1		1		1
H106	Same as H105	Clamps power supply output cable to power supply tray.													
H107	HANDLE, case: brass, black wrinkle; 5¾″ lg x 1½″ wd x 1⅜″ thk.	Case handle.				Stanley Works No. 482¼NS–2	1.001 dwg 1–1293	H107	1		0		0		1

Table 5-2
H108-H115

H108	CLAMP, capacitor: brass, nickel plate; single center bolt; 1 11/16" lg x 1/2" wd x 5/32" h.	Holds paper capacitors.		Cardwell	3.248 dwg LM-74	H108	1	0	0	1
H109	CLAMP, midget tube: phosphor bronze, nickel plate; single bolt; 1 3/8" lg x 1/2" wd x 1 1/32" h.	Tube retainer.		Cardwell	3.416 dwg 173-V	H109	2	0	0	2
H110	FASTENER, latch: phone compartment cover; brass, nickel plated; 13/16" lg x 39/64" h x 3/8" wd.	Fastens phone compartment door.		Cardwell	Part No. 1.045 through 1.051	H110	2	0	0	2
H111	FASTENER, latch: fastens rear door; brass, nickel plated, 19/32" lg x 1/2" wd x 11/32" lg.	Fastens rear compartment door.		Cardwell	Part No. 1.090 through 1.094	H111	2	0	0	2
	STRAP, carrying: SIG C, ST-19-A; olive drab cotton webbing; 4' 6" lg x 2" wd x 1/8" thk.	Carries case.	2Z9019A				1	0	0	1
H112	FASTENER, Dzus: on chassis; brass, nickel plated; 2 13/16" lg x 5/8" diam.	Fastens chassis in carrying case.	3Z3850	Cardwell		H112	2	0	0	2
H113	FASTENER, latch: door; black, nickel plated; 2" lg x 1" wd x 15/32" h.	Fastens door to upper section of carrying case.		Excelsior Hdwe. 044000PN	1.059 dwg 1-1295	H113	1	0	0	1
H114	CLAMP ASSEMBLY: brass, nickel plated; two No. 2-56 screws; 3/4" lg x 7/16" wd x 3/32" thk.	Locks units dial.		Cardwell	113.020, 3.019, 3.155 dwg 1-876, 1-877 WF-1030	H114	1	0	0	1
H115	BRACKET, Dzus fastener: in carrying case; brass, nickel plated; 2 1/2" lg x 1 3/16" wd x 3/4" h.	Fastens chassis in carrying case.	2Z1239.46	Cardwell	1.016 1.017 dwg 1-926, 1-927	H115	2	0	0	2

TABLE 5-2

COMBINED PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATION — (Continued)

FOR NAVY TYPE TS-173/UR

PARTS										SPARE PARTS					
										EQUIP.		TENDER		STOCK	
SYMBOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN. OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRACTOR'S DWG. AND PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED	TOTAL NO. PER EQUIP.	Box No.	Quan.	Box No.	Quan.	Box No.	Quan.
J100	CONNECTOR, female contact: 2 contacts central, round female outer, circular; straight; 1 5/16" lg x 1" wd x 1" h; furnished w/ 6" lead.	Antenna jack.	Navy type 49206		1F4C6–1.6	Cardwell	A3.303 dwg WF–A1403	J100	1		0		1		2
J101	JACK, telephone: for 2 conductor 0.25" diam plug; 3 7/16" lg x 15/16" wd x 27/32" h.	Panel phones jack.	Navy type C–49025A		ZC1411B/J1	Mallory B113464 sub 1	10.000 dwg 1–792	J101, J102	2		1		2		4
J102	Same as J101	Panel phones jack.	Navy type C–49025A		ZC1411B/J1										
J103	CONNECTOR, female contact: round contact: straight; banana, approx diam head 3/16"; phosphor bronze; 19/32" lg x 3/8" diam.	Chassis ground connector.			2Z5574.1	General Radio 274–J	3.049 dwg 1–1515	J103, J104 J105 J106 J107	6		3		6		12
J104	Same as J103	Chassis B + connector.			2Z5574.1										
J105	Same as J103	Chassis filament connector.			2Z5574.1										
J106	Same as J103	Connectors for power switch leads.			2Z5574.1										
J107	Same as J103	Connectors for power switch leads.			2Z5574.1										

L1	See C1	Heterodyne osc inductor.										
L2	See C1	Heterodyne osc inductor.										
L3	COIL, radio, RF: integral type; single winding; unshielded; .175 mh; 1/4" h x 21/32" diam; mounted in bakelite case 7/8" wd x 7/8" lg x 1/2" h; wound in accordance w/ Navy spec RE-13A-700A.	Mixer and crystal oscillator cathode choke.	Sickles	8.054 dwg FW-1312	L3	1	1	1	1			1
L4	COIL, radio, RF: integral type; single winding; unshielded; .035 mh; wound in accordance w/ Navy spec RE-13A-700A.	Crystal plate choke.	Sickles	8.057 dwg 173-DR	L4	1	1	1	1			1
L5	COIL, radio RF: integral type; 4 pie universal wound; unshielded; .795 mh; 7/8" lg x 3/8" diam; mounted in bakelite sleeve 1" lg x 1/2" diam; wound in accordance w/ Navy spec RF-13A-700A.	Mixer plate choke.	Sickles	7.050 dwg 173-DA	L5	1	1	1	1			1
L6	COIL, radio AF: filter; single winding; 20 h; 35 ma; 40 ohms; enclosed in metal case 2 1/8" lg x 2 1/4" wd x 4" h; wound in accordance w/ Navy spec RE-13A-553B.	Filter choke.	Freed 12249	10.067	L6, L7	2	2	4				6
L7	Same as L6.	Filter choke.										
O101	CRANK ASSEMBLY, tuning: knob, black catalin or plastic; shield blackened aluminum alloy; knob, 3/8" lg x 5/16" diam; shield 1/2" lg x 1 23/32" OD x .061" thk.	Varies osc capacitor.	Cardwell	A4.199 dwg WF-1132	0101	1	0	0				1
			2Z3407.24									

TABLE 5-2

COMBINED PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATION — (Continued)

FOR NAVY TYPE TS-173/UR

PARTS										SPARE PARTS					
										EQUIP.		TENDER		STOCK	
SYM-BOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN. OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRAC-TOR'S DWG. AND PART NO.	ALL SYMBOL DESIG-NATIONS IN-VOLVED	TOTAL NO. PER EQUIP.	Box No.	Quan.	Box No.	Quan.	Box No.	Quan.
P103	CONNECTOR, male: banana cont; phosphor bronze, diam head approx 3/16"; 1 1/32" lg x 3/16" diam.	Chassis ground.			2Z1227-4	Amer Rad Hdwe 2616	1.767 dwg 1-1232	P104 P105 P106 P107	4		2		4		8
P104	CONNECTOR, male: banana cont; phosphor bronze, diam head approx 3/16"; 13/16" lg x 3/16" diam.	B + connector.			2Z3021-57			P104							
P105	Same as P104	Filament voltage connector.			3E7262										
P106	Same as P104	AC switch connector.			3E7262										
P107	Same as P104	AC switch connector.			3E7262										
R1	RESISTOR, variable: carbon; 1000 ohms + 20%; lw; 3 terminals; 1 1/8" diam x 9/16" lg; special brass shaft 3 3/4" lg (two potentiometers mounted on single shaft w/ special shielding).	Attenuator (dual).	JAN-R-19 type RA 15A1RA 102AK			Clarostat D-37-W linear taper	10.021 dwg 1-1445	R1	1		1		3		5
R2	Same as R4 (see C1)	Heterodyne osc 9002 grid leak.	JAN-R-11 type RC 20BE209K		3Z6720-32										

R3	RESISTOR, fixed: composition; 15,000 ohms ± 10%; ½ w; 9/64" diam x 3/8" lg.	Heterodyne osc 9002 plate resistor.	JAN–R–11 type RC 20BE 153K	3RCZ1BE 153K	AB EB–1531 dwg Y–3860–D	3.276 dwg WF–1301	R3	1	1	2	3
R4	RESISTOR, fixed: composition; 200,000 ohms + 10%; ½ w; 9/64" diam x 3/8" lg.	Mixer 9001 grid leak.	JAN–R–11 type RC 20BE204K	3Z6720–32	AB EB–2041	3.164 dwg WF–1043	R2, R4, R7, R11, R-14	4	2	6	10
R5	RESISTOR, fixed: composition; 1 meg ±20%; ½ w; 9/64" diam x 3/8" lg; in accordance w/ JAN–R–11 spec.	Mixer 9001 screen resistor.	JAN–R–11 type RC20BE 106K	3RC30BE 105M	AB EB–1051 dwg Y–3860–D	3.280	R5, R10, R12	3	2	4	8
R6	RESISTOR, fixed: composition; 150,000 ohm ± 10%; ½ w; 9/64" diam x 3/8" lg.	Crystal grid leak.	JAN–R–11 type RC 20BE154K	3RC30BE 154K	AB EB–1541 dwg Y–3860–D	3.163 dwg WF–1043	R6	1	1	2	3
R7	Same as R4	Mixer 9001 plate resistor.	JAN–R–11 type RC20BE20–4K	3Z6720–32							
R8	RESISTOR, variable: carbon; 1 meg ± 20%; ½ w; three terminals; 1⅛" diam x 9/16" lg; shaft ¼" diam x 4¼" lg.	Gain control.	JAN–R–19 type RA15A1RA 105AK	2Z7273–6	Clarostat 37–W Z taper	10.040 dwg WF–1302	R8	1	1	3	5
R9	RESISTOR, fixed: composition; 5,000 ohms ± 10%; ½ w.	Amp 9001 cathode resistor.	JAN–R–11 type RC20BE50 2K	3RC30 BE502K	AB EB–5021	9.042	R9	1	1	2	3
R10	Same as R5	Amplifier 9001 screen resistor.	JAN–R–11 type RC20BE10 6K	3RC30BE 105M							
R11	Same as R4	Amplifier 9001 plate resistor	JAN–R–11 type RC20BE20 4K	3Z6720–32							
R12	Same as R5	Amplifier 9002 grid leak.	JAN–R–11 type RC20BE 106K	3RC30BE 105M							

TABLE 5-2

COMBINED PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATION — (Continued)

FOR NAVY TYPE TS-173/UR

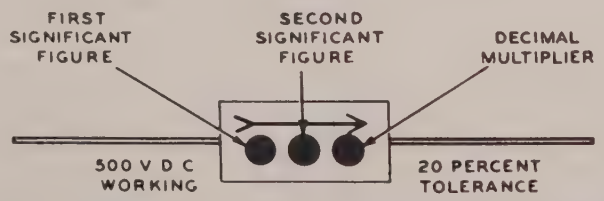
PARTS										SPARE PARTS					
										EQUIP.		TENDER		STOCK	
SYM-BOL DESIG.	NAME OF PART AND DESCRIPTION	FUNCTION	AWS, JAN, OR NAVY TYPE DESIG.	NAVY STOCK NO.	ARMY STOCK NO.	MFR. AND MFR'S DESIG.	CONTRACTOR'S DWG. AND PART NO.	ALL SYMBOL DESIGNATIONS INVOLVED	TOTAL NO. PER EQUIP.	Box No.	Quan.	Box No.	Quan.	Box No.	Quan.
R13	RESISTOR, fixed: composition; 750 ohms ± 10%; ½ w; 9/64″ diam x 3/8″ lg.	Amplifier 9002 cathode resistor.	JAN–R–11 type RC20BE751K		3Z6075–40	AB EB–7511 dwg Y–3860–D	3.161 dwg WF–1043	R12	1		1		2		3
R14	Same as R4	Decoupling.	JAN–R–11 type RC 20BE204K		326720–32										
S1	SWITCH, toggle: DPDT; bakelite; 1 5/32″ lg x 11/16″ wd x 1¾″ h.	Modulation switch.			3Z8142.1	10.023 dwg WF–1033	Cutler-Hammer 8363–K2	S1	1		1		1		1
S2	SWITCH, rotary: 3-pole, 5-position; 2 decks; bakelite; 1 7/8″ lg x 1½″ wd x 1 15/16″ h.	Operate switch.			3Z9825–5892	10.025 dwg. WF–1046	Globe-Union 2AH–7569	S2	1		1		1		1
T1	TRANSFORMER, AF: output; aluminum cam; ⅞″ diam x 1½″ h; pri 100 ohms; secd 4000 ohms.	Output transf.			2Z9632.316	United Trans 82806	10.026 dwg WF–1047	T1	1		1		2		3
T2	TRANSFORMER, power: plate and filament; fully enclosed steel case, 3″ lg x 2 5/8″ wd x 3 13/16″ h.	Power transf				Freed Trans 12595	10.066	T2	1		1		2		3
V1	TUBE, electron: UHF; midget triode.	Heterodyne osc.	JAN9002			Kenrad	10.043	V1, V3, V5	3		6		9		0
V2	TUBE, electron: JAN 9001; UHF detector amplifier pentode.	Mixer	JAN9001			Kenrad	10.074	V2, V4	2		4		6		0
V3	Same as V1.	Crystal osc.	JAN9002												

Table 5-2
V4-Y1

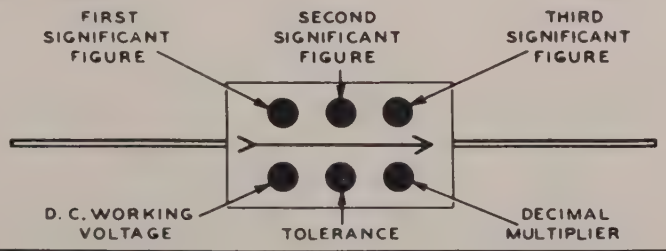
V4	Same as V2	Amplifier pentode.	JAN9001									
V5	Same as V1.	Amplifier output stage.	JAN9002									
V6	TUBE, electron: JAN 6X5G; full wave high vacuum rectifier.	Full wave rectifier.	JAN6X5G		RCA	10.060	V6	1	0	3	0	
V7	TUBE, electron: JAN OD3/VR-150/30; voltage regulator.	Voltage regulator.	JAN OD3/VR-150/30		Sylvania	10.061	V7	1	2	3	0	
X1	SOCKET, tube: 7-prong miniature; ceramic; 1 3/16" lg x 3/4" wd x 1/2" h.	Socket for miniature tube JAN9002		2Z8699-12	Johnson 267	10.077 dwg 173-DU	X1					
X2	SOCKET, tube: 7-prong miniature; molded bakelite; 1 1/8" lg x .8" diam; supplied with S053 shield.	Socket for 9001	S010M		Cinch T9319FV	10.082 dwg 173-ET	X2, X3, X4, X5	4	3	3	5	
X3	Same as X2.	Socket for 9002.										
X4	Same as X2.	Socket for 9001.										
X5	Same as X2.	Socket for 9002.										
X6	SOCKET, tube: octal; moulded mica filled insulation; 1 5/8" lg x 1 3/16" wd x 1/2" h.	Socket for JAN6X5G		2Z854	Amphenol 88-8-TM	10.008 1.1590	X6, X7, X8	3	2	2	3	
X7	Same as X6.	Socket for JAN OD3/VR/150/30		2Z854								
X8	Same as X6.	Crystal holder socket.		2Z854								
Y1	CRYSTAL UNIT, quartz: single wafer; frequency 5000.0 KC; metal holder; 2 13/16" lg x 15/16" diam; plug in type w/ 8-prong base for octal socket.	Crystal standard.	CG-40175 CG		General Electric	10.075 173-DX	Y1	1	1	1	1	

TABLE 5-3
APPLICABLE COLOR CODES

FOR CAPACITORS (MMFD)



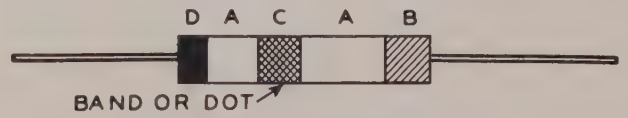
COLOR	NUMERAL	VOLTS	MULTIPLIER	TOLERANCE
BLACK	0		1	
BROWN	1	100	10	1%
RED	2	200	100	2%
ORANGE	3	300	1,000	3%
YELLOW	4	400	10,000	4%
GREEN	5	500	100,000	5%
BLUE	6	600	1,000,000	6%
VIOLET	7	700	10,000,000	7%
GRAY	8	800	100,000,000	8%
WHITE	9	900	1,000,000,000	9%
GOLD		1000	0.1	5%
SILVER		2000	0.01	10%
NO COLOR		500		20%



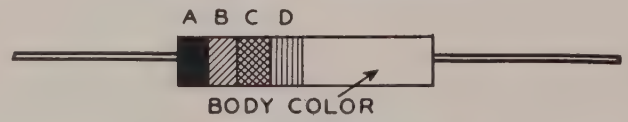
FOR RESISTORS (OHMS)

COLOR	A 1st DIGIT	B 2nd DIGIT	C MULTIPLIER
SILVER			0.01
GOLD			0.1
BLACK		0	1.0
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
PURPLE	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	

D — TOLERANCE CODE:
GOLD = 5% SILVER = 10% NO COLOR = 20%



OLD COLOR ARRANGEMENT



NEW COLOR ARRANGEMENT

BODY COLOR (NEW COLOR ARRANGEMENT ONLY) INDICATES TYPE OF RESISTOR, AS FOLLOWS:—
BLACK — COMPOSITION, NON-INSULATED
TAN, OLIVE OR WHITE — COMPOSITION, INSULATED
DARK BROWN — WIRE-WOUND, INSULATED

TABLE 5-4
LIST OF MANUFACTURERS

ABBREVIATION	MFR'S PREFIX LETTERS	NAME OF MANUFACTURER	CORRESPONDENCE ADDRESS
AB	CBZ	Allen-Bradley Company	118 W. Greenfield Ave. Milwaukee 4, Wisconsin
Amer. Hdwe.	CNH	American Radio Hardware Co., Inc.	476 Broadway New York, N. Y.
Amphenol	CPH	American Phenolic Corporation	1830 S. 54th Street Chicago 50, Illinois
Birtcher	CAIS	Birtcher Corporation	5087 Huntingdon North Los Angeles, California
Bristolco	CTB	Bristol Company	117 Bristol Road Waterbury 91, Connecticut
Buss	CFA	Bussman Manufacturing Company	Jefferson & University Streets St. Louis 7, Missouri
Cardwell	CBK	The Allen D. Cardwell Manufacturing Corp.	81 Prospect Street Brooklyn 1, New York
Cinch	CMG	Cinch Manufacturing Company	2339 W. Van Buren Street Chicago, Ill.
Clarostat	CMC	Clarostat Manufacturing Company	130 Clinton Street Brooklyn, New York
C-H	CAE	Cutler-Hammer, Inc.	1333 West Street, St. Paul Ave. Milwaukee, Wisconsin
Dubilier	CD	Cornell-Dubilier Electric Corporation	1000 Hamilton Blvd. S. Plainfield, N. J.
Elec. Utilities	CEU	Electrical Utilities Company	2427 St. Vincent Avenue La Salle, Illinois
Erie	CER	Erie Resistor Company	644 W. 12th Street Erie, Pennsylvania
Excelsior Hdwe.		Excelsior Hardware Company	Woodland Avenue Stamford, Connecticut
Freed Trans.	CFX	Freed Transformer Company	72 Spring Street New York 12, New York
GE	CG	General Electric Company	1 River Road Schenectady, New York
GR	CAG	General Radio Company	30 State Street Cambridge, Massachusetts
Globe-Union		Globe-Union, Inc.	900 E. Keefe Avenue Milwaukee, Wisconsin
Johnson EF	CKR	E. F. Johnson Company	206 Second Avenue, S.W. Waseca, Minnesota
Kenrad	CEJ	Ken-Rad Tube & Lamp Corporation	316 E. 9th Street Owensboro, Kentucky
Littelfuse	CLF	Littelfuse Laboratories, Inc.	4757 N. Ravenswood Avenue Chicago 40, Illinois
Mallory	CMA	P. R. Mallory Company	3029 Washington Street Indianapolis 6, Indiana
Micamold	CMR	Micamold Radio Corporation	1087 Flushing Avenue Brooklyn, New York
RCA	CRC	Radio Corporation of America Manufacturing Company	Harrison, N. J.

LIST OF MANUFACTURERS—(Continued)

ABBREVIATION	MFR'S PREFIX LETTERS	NAME OF MANUFACTURER	CORRESPONDENCE ADDRESS
Sickles FW	CFW	F. W. Sickles Company	165 Front Street Chicago, Illinois
Solar	CSL	Solar Mfg. Corporation	285 Madison Avenue New York 17, New York
Stanley Tools		The Stanley Tools Division, The Stanley Works	195 Lake Street New Britain, Connecticut
Sylvania Prod.	CHS	Sylvania Electric Products, Inc.	Ipswich, Massachusetts
UTC	CUT	United Transformer Corp.	150 Varick Street New York 13, N. Y.

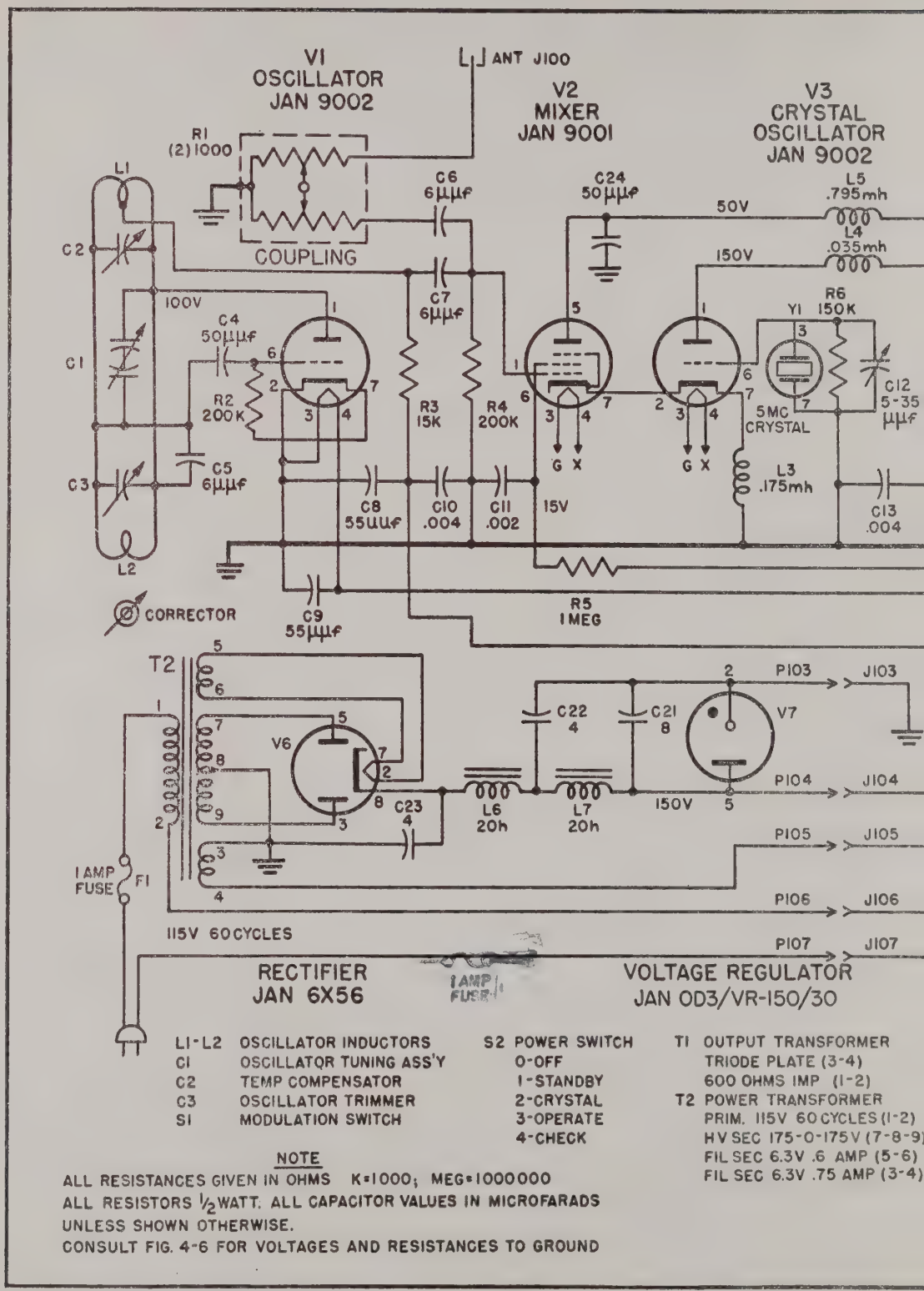


Fig. 4-9. Complete Circuit Schematic.

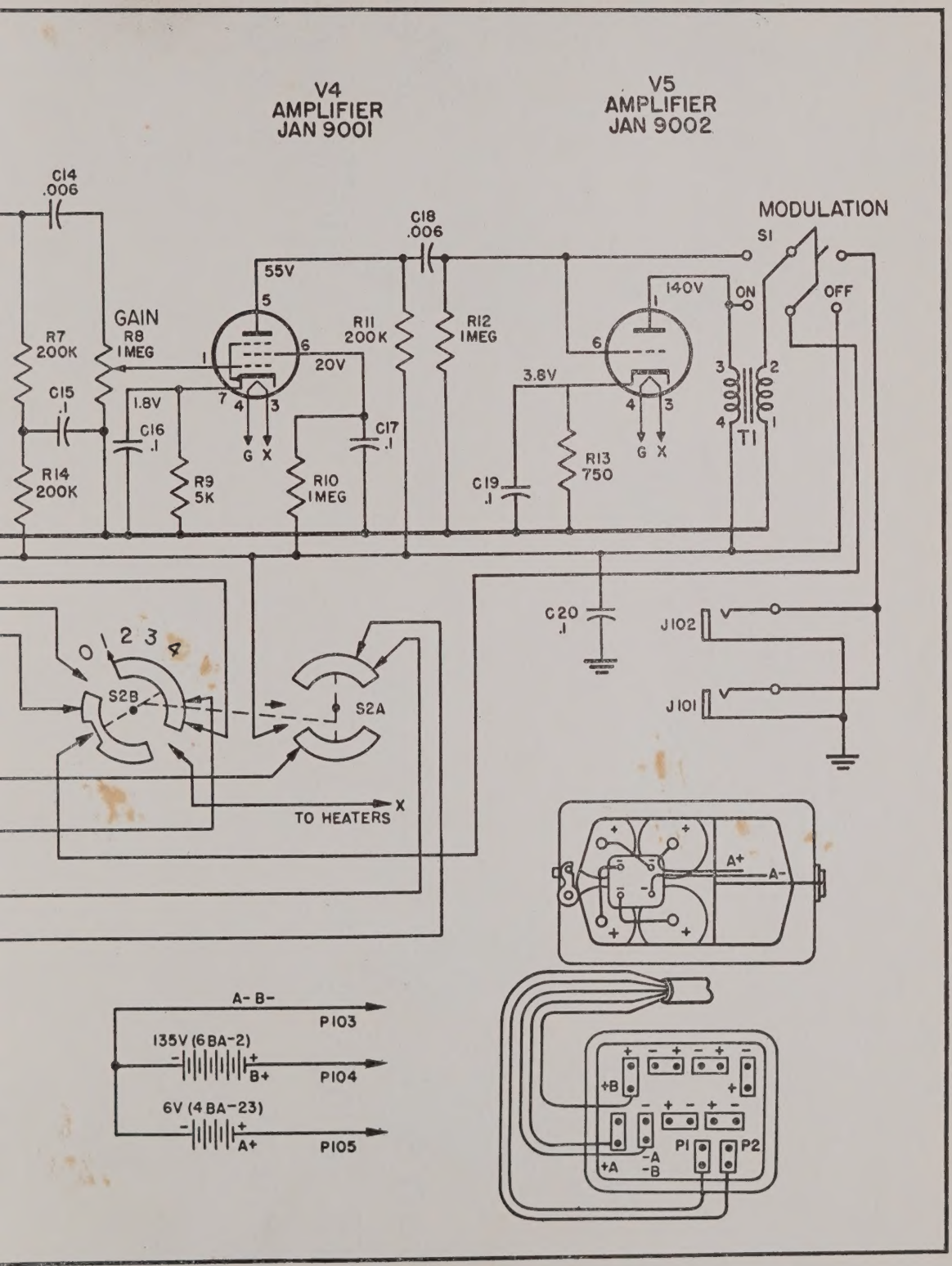


Fig. 4-9. Complete Circuit Schematic.

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